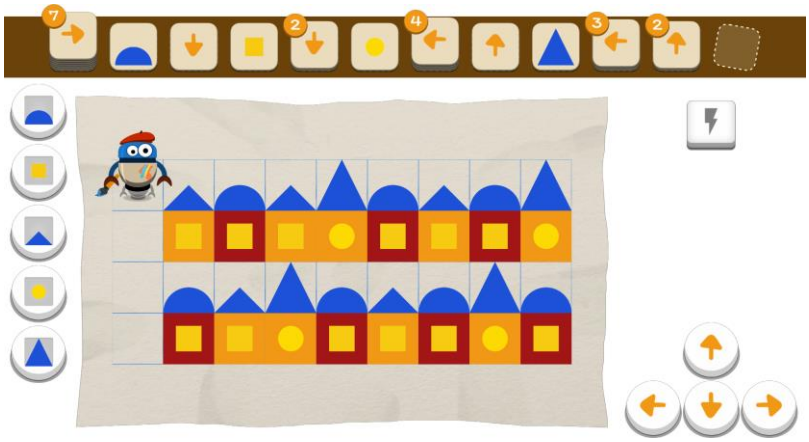
Third world – Emil the Artist

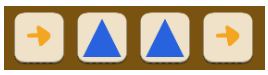
Just as it was the case in the second world, we would not like to dive into details while introducing Emil's third world as the readers have become familiar with it at their PD session. This part should only help with clarifying correct and consistent names and terms for the individual components of 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 elemnts and a task assignment, which are identical to the first world with the exception of colour, which has changed from green and blue – used in the first and the second worlds – to brown):



Again, Emil's **stage** contains **positions**, which are not clickable — all **controls** (used to navigate Emil on the stage) are handled by navigation arrows: up, down, left and right. However, this world does not offer tools that manipulate the individual positions such as basket, light bulb etc. Instead, there is a new kind of tools situated in the left part of the screen: **coloured pieces** that can be placed on the stage. Each piece has a specific **shape** and **colour**. Initially, each piece is presented as a particular tool that is used to place it; however, starting with task **B3**, the pieces will be accompanied by a **tool to rotate** them (giving us the ability to turn the pieces by 90 degrees clockwise, however only immediately after placing them). As soon as Emil places a piece into a position on the stage over which he is currently "hovering", the piece becomes a part of the stage. Emil cannot change this choice except by cancelling the whole command that made him perform the action (see below). However, he can place another piece on the same position without any limitations.

Again, there is a (brown) **panel** above Emil's stage, with either a fixed or unlimited number of empty **places**. Each command given to Emil – using a navigation arrow or a piece placement tool – will be indicated on the panel by a small **sign** or a **card**. We will talk about **cards** with commands being placed on the panel. The panel will, again, serve as a **record** of commands given to Emil or as an eventual **plan** or **program** of commands to be executed later by Emil. Just as we were thinking about the **order of shapes on the shelf** in the first world, the pupils will spend their time in the second and third worlds developing their **perception of the order of commands on the panel.** The panel thus represents an opportunity to familiarise with a key concept of programming – the **order of commands**.



As we can see in several pictures shown on this page, this world, too, contains the feature of **stacking** a series of the identical commands on the panel, present from unit **A** on. However, it should be noted that this is only true for the arrows, not for the placement of pieces (see the left panel on the picture above). This is because there is an option to place the same piece on the same position twice, whilst rotating them differently. When placing a piece, the panel also indicates whether the piece was rotated (using the rotation tool) or not. The possible states are **none**, i.e. without a **rotation mark**, **once**, **twice** or **three times** (see top-right part). After four rotations, the piece returns to the original state and appearance.

Starting with the **before F** and **F** units of tasks, new elements will appear to the right of the stage: one, two or three **memories**. To the left of the stage, new **memory execution** tools will appear next to the piece placement tools, taking appearance of a **green**, **red** or **violet** "memory card" or sign of a memory.

The purpose of those memories is explained further in the respective section of this teacher's material. We will learn that the memory contains several commands for Emil — arrows or piece placement — and that this group can be "replaced" on the panel with a simple **sign of a memory** coloured green, red or violet.

The sign of a memory in the record or program thus functions as a **shortcut** representation of a whole group of commands. In the example on the previous page, the green memory serves as a replacement to four commands: place a blue rectangle, place a red roof, place a black square as a door and move right to the next position.

Workbook hard paper supplement

Pages III, IV, V, VI and the lower part of page IX of the hard paper supplement belong to this world. We provide a detailed explanation of their use in this teachers' material in the part discussing the **after B** unit of tasks (pages V and VI) – and we make use of these cutouts from the tasks **after B** onwards, and then in the part dedicated to tasks **before F** (all other pages): those paper cutouts will be used when working on tasks **before F1**, **before F2** as a preparation for all of the subsequent units of tasks, i.e. **F**, **after F**, **G**, **H**, and **after H**, i.e. when dealing with tasks that require to work with Emil's memories.

Map of the complete intervention

This world consists of 14 units of tasks, of which the units **after B**, **after D**, **after E**, **before F**, **after F**, and **after H** can only be found in the workbook. With the exception of the tasks in 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 implementation of all activities in the third 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.

Abridged implementation for the third world

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

In particular, should the teacher opt for an abridged implementation, the pupils will not have an opportunity to gain experience in planning solutions to tasks which will also require Emil to rotate pieces, i.e. with planning of the rotations (using paper cut-outs). Furthermore, the pupils will miss out on reading and executing programs that work with the rotate command and skip opportunities to gain more experience reading the pre-made memories and executing programs that make use of them, as well as skip the creation of programs for Emil that take advantage of the pre-made memories. Last but not least, they will not learn to complete partially built memories. However, the pupils would become familiar with the memories in groups **before F** and **F**. Let us notice that in the abridged progression, the pupils do not work with units of tasks **after E**, **after F** and **after H** but still use the workbook when working with groups **A**, **B**, **after B**, **C**, **after D**, **before F** a **F**.

Should the teacher opt for the minimal implementation, the pupils will become familiar with the way in which they can navigate Emil around the stage and place various pieces on it, think about the order of placement of the individual pieces, become familiar with the rotate tool used to manipulate the pieces, analyse and create various repeating patterns, learn how to send their creations from Emil's e-mail address as attachments to their messages, plan ahead a complete solution to Emil's tasks and only let Emil execute the plan (program) at the very end, and to execute these programs in their workbooks step by step — however, skipping the piece rotation. That said, they would not encounter Emil's memories at all. Let us notice that in the minimal implementation, the pupils only complete one **after…** unit of tasks, namely **after D**. Still, they work with the workbook when completing tasks from groups **A**, **B** and **C**.

On the other hand, we would like to repeat that:

- compared to the minimal variant, even the abridged intervention will provide better support of the pupils' learning process when exploring the basics of programming, and that the minimal intervention is always much more useful for the pupils than no intervention at all,
- the teacher may perform one of the abridged interventions of any of Emil's 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 Artist • A

Educational objectives

- To explore the third world of Emil and find out how Emil can move around.
- To become familiar with a new type of tools that Emil uses to **place coloured pieces** in the positions on the stage.
- To discover a new way of moving Emil between rows and columns (the so-called **teleportation**).
- To think about repeating **patterns** on the stage, to think about the **order of placing multiple pieces** on a given position.
- To work with a **limited** or an **unlimited number of steps** when completing tasks.

Computing-specific content

The manner in which we navigate Emil along the stage is the same as in the second world. However, he also has new tools that are located left of the stage and each of them indicates the **shape and colour of the piece** that Emil will place on his current position on the stage using this tool.

Many of these tasks strengthen the pupils' **perception of shapes** (an important connection to mathematics) and their **sense of colour** and **perception of patterns**, particularly those that repeat in varying ways (a feature of a key importance for computing).

As before, pupils will start by **direct control of Emil**, i.e. by giving commands which he **immediately executes**. At the same time — just like in the second world, a **record** of these commands is made on the panel above Emil. Almost always, the panel has a limited number of available places. That is why the pupils need to complete the task using the lowest possible number of steps.

Either now or later, the pupils will realize that it is possible to **erase the last card on the record by clicking on it**. Emil then returns to the previous situation.

The pupils will also see that Emil can now **teleport**: stepping right from the rightmost position on the stage will take Emil to the left edge of the following row. Similarly, Emil teleports downward (to the top of the next column), but also leftward and upward (however, teleporting in these directions is not as intuitive and we do not expect it to be used in the tasks). This means that we basically need only the right and down arrows — or even just one, in rare cases — to complete the tasks.

Another key computing concept in this unit of tasks is the **order of imprinting**: to construct a road sign marking the priority road, Emil first needs to imprint a white diamond followed by a smaller, yellow one, and **not the other way around**.

Teacher support and commentaries

A1

S: Place the missing roofs onto the shadows.

The pupils gradually become familiar with a new kind of tasks and tools — on the left edge of Emil's stage, they see two blue pieces that only differ in their rotation. The pupils are to place the correct shape in the correct position as indicated by the shadows above the houses. They will notice that there is a panel above the stage again (usually containing a limited number of places, which represent the maximum number of steps to reach the solution of the task), containing the record of commands. In additions, identical commands which go together are grouped in stacks again.

Since Emil begins in the top row of the stage and both missing roofs are in the top rows, the pupils will be able to place the missing pieces of the houses correctly (which will not always be the case in the following task).

A2

S: Place the missing roofs onto the shadows and get back. Complete the task in the workbook.
WB: In the table, write how many times each command was used.

A similar task. This time, however, one of the houses has a different shape of the window and Emil can choose from three different tools. The pupils need to pay attention to the shapes of the houses and to choose the right roof (the shadows above the houses will help them). Another difference is that Emil begins in the bottom row, which requires the pupils not only to navigate him to the right side, but also to the top row. Some will make mistakes and "miss" the correct placement of the roofs:

However, this will allow the pupils to correct their last incorrect step. What's even more important, though, is the experience of seeing that Emil places the piece on the position "behind" him, not "above" him.

A major part of the task is the table in the workbook for the pupils to write down the numbers of individual commands in their solutions.

A3

S: Follow the task in the workbook.
WB: Add the missing roofs and windows according to the picture and get back.
Fill in the table.

Another similar task, but with three kinds of houses placed in two rows. Sometimes, the houses lack a window, other times, it's a roof, or even both. Now, Emil can select from several pieces. One of them will not be necessary at all. The

pupils need to be careful when planning the order in which Emil will be placing the individual pieces so that he can complete the whole task and return to his place (marked by a small shadow of Emil).

Again, the pupils need to complete the table in their workbooks, but this time, they need to write down the number of various kinds of houses on the stage.

A4

S: Finish the traffic signs and get back. Complete the task in the workbook.
WB: Write the names of the traffic signs.

This task focuses on the **order of placement of the pieces**: both road signs, which are first visible as shadows only, need to be assembled from two parts that the pupils stack on one another. If the pupil placed the white triangle first and followed by the larger, red one, the white triangle would be covered by it.

Two other road signs are already partially assembled, but pupils may decide, which of them they will complete to make the "no entry" sign and which of them will become the "one-way traffic" sign. We would like the pupils to notice the **ambiguity** and discuss it. In the workbook, they will write down names of the road signs to the respective pictures.

A5

S: Once again: finish the traffic signs and get back. Complete the task in the workbook.
WB: How many times did you use the right arrow with Emil?
Now draw your own traffic sign, for example 'Beware of Robot' or a different one.

This task is similar to the previous one, but this time, the pupils will notice that only one arrow is available. Some might be confused, other might experiment until they find out that by using the right arrow when Emil is located on the right edge, they will move him to the left edge in the row below, which is similar to the behaviour of text editors. The news about the discovery of **teleportation** will quickly spread throughout the class. Its other "forms" such as the movement from the bottom of a column to the top of an adjacent column will come naturally to pupils in later tasks.

The pupils will then continue with the completion of the task in the workbook.

A6

S: Finish the pattern and get back.

Another task dedicated to practicing teleportation and developing the perception of repeating patterns. The number of places on the panel is limited, which means that we can only complete the task (and return to the starting point) when moving Emil in the same direction for a longer time. There are two solutions shown in the picture, but there are also other open possibilities:

A7

S: Finish all the fish in the aquarium.

A task dedicated to practicing teleportation and developing the perception of repeating patterns.

A8

S: Look, two blocks of flats. Fill in the white areas. Then complete the task in the workbook.
WB: Draw the path Emil took in the stage to complete the task.

A task focused on working with shapes and teleporting between columns.

Group discussion

(comparison with the second world) *How is Emil's third world different from the second one?* (The way in which we navigate Emil is the same, but the tools are different and serve a different purpose: they do not change the state of a position as was the case when watering or lighting fires. The tools in this world place the selected piece in Emil's current position. Thanks to that, we can control Emil to create or complete a picture, a pattern etc.) *Is the panel any different? Are the same commands still stacked?*

(A1) *How many kinds of houses are there on Emil's stage? Let's describe them in detail* (an orange one with a yellow window and a low blue roof and a red one with a yellow window and a tall blue roof). *How many of them are there for each type? How many places on the panel above the stage did you fill in? How many **right** arrows in total did you use?*

(A2) *Did you add all of the missing roofs? Did you return Emil to his starting point? How did you know where to come back?*

(A3) *How many different pieces can Emil use now? How many of them did you actually use? How did you know which window and which roof to use? Didn't you need the roof shadows? Did anyone fill the whole panel before completing the task?*

(A4) *Which traffic sign did you complete first? In which order did you place the pieces? Which ones were they? Would it be possible to do it in reverse order? How did you know what you should add to the two unfinished red road signs?*

(A5) *How did you complete the task when there is only one arrow now?*

(A6) *Would it be possible to complete this task if we only had the down arrow instead?*

(A7) *In a couple of words, describe the appearance of the green fish and the blue fish. How many pieces is it made of?*

(A8) *Is there any other solution to this task?* (depends on what exactly we mean: only one arrow is available, but we can still complete the houses in a different order…)

(about the whole unit of tasks) *Did anyone give Emil an incorrect order? Can we fix this kind of error?* (we can click the last command recorded on the panel, continue with the one before etc.)

Emil the Artist • B

Educational objectives

- To recognize various **rotations** of the same piece. To analyse the patterns that contain various rotations of the same piece.
- To discover and study Emil's new **tool for rotating pieces** after having placed them in the position.
- To think about a complex pattern consisting of a small number of shapes with various rotations. To **complete** such patterns with correctly rotated missing pieces.
- To **replicate** the given patterns consisting of several equal pieces of different colours that are rotated differently.
- To **correct an erroneous command** given to Emil by the pupil.
- To think about **the rotation of the pieces and the order of their layering.**

Computing-specific content

In these tasks, the computing-specific content overlaps significantly with mathematics given that the pupils learn to recognize various basic **shapes that are rotated in a number of angles** (either in the "zero" rotation, or rotated by 90 degrees and twice or three times as much). The pupils also learn to analyse various patterns and think about what basic shapes — pieces —are repeated in them, not forgetting that they might be rotated differently. However, the computing-specific content becomes evident in the fact that the pupils need to think about how to create the patterns from a given set of pieces: they need to consider the rotation of every piece and the **order** in which they need Emil to place them in order to form the pattern.

To rotate the piece, the pupils will have Emil use a special tool — if they do not use it, Emil will place the piece in place in its basic rotation. However, Emil can use **the rotate tool** immediately after placement — once, twice or three times. The fourth rotation is possible as well, but that only returns the piece to its original appearance. As soon as Emil leaves the position or places another piece on it, he **loses the ability** to rotate the previous piece (unless he cancels some of the previous steps — see below). Even though to recognize various rotations of the individual pieces might be quite a demanding task for pupils at this age, it is made easier by a fair amount thanks to Emil's movement (animation) that occurs after each use of the rotate tool.

In addition to recognizing the pieces in various positions, the pupils thus learn to **analyse patterns** and to think about the elements and rotations that are needed to create them (or replicate them symmetrically as mirror images).

Another important computing concept is the possibility to **correct an error** in their steps (commands) that Emil was tasked with, and the manner in which the correction is performed. Whilst in the second world, it was impossible to cancel a mistake (or, better said, a command that the pupils gave Emil but later changed their mind about how to proceed), it is very much possible to do so in the third world. To cancel a command, we simply click the last command in the record of commands (steps) on the panel. This step can be repeated, which means that we can cancel the commands, one at a time, from "backwards". Note that in the second world, the pupils could only change their decision if they programmed Emil's future behaviour, assuming that they used a dedicated eraser tool for doing so.

Teacher support and commentaries

Whilst completing the unit of tasks, the pupils will realize that Emil does not imprint (or stamp) his pieces on the stage. Instead, he places them into their positions and can rotate them as well — but only the most recently placed piece. In that case, the (90°) rotation of the shape is indicated by an animation. The piece can be rotated once, twice or three times — another rotation would return the shape to its original position.

***S:** Follow the task in the workbook.*
***WB:** Emil needs to finish the pattern of tiles. Follow these steps:*
1. Count how many of each piece he will need and fill in the table.
2. Add the missing tiles with Emil and check that you have filled it in correctly.

A preparatory task for piece rotation: Working on the task, the pupils will realize that the same shape can be used in a picture in four different rotations. That is why the written instructions in the workbook tell them to examine the picture on Emil's stage and complete a table that will indicate the number of individual shapes which they will need to complete the whole pattern. (Note: when the task is completed on the computer, we cannot determine the number of individual pieces that were needed because we do not see the whole record panel.)

When working on part 2 of the task from the workbook, the pupils may record each placed piece by drawing a mark in the respective cell of the table, below the number they had calculated before. We want them to realize that all four pieces actually represent the same shape, but in different rotations.

B2

S: Once again: finish the pattern of tiles.

Again, the pupils need to complete the task with the same pattern, but this time, some yellow and green pieces are missing as well. Moreover, we do not see the shadows in the place of the missing parts. Whilst completing the task, the pupils thus have to consider the whole pattern and its structure, including the individual shapes, their colours and their rotation.

B3

S: Play with the rotation command. Follow the task in the workbook.
WB: Help Emil to replicate the upper line in the lower line.
Write how many times Emil had to rotate each triangle in your program.

In this task, the pupils become familiar with the **rotate tool** — they have to follow the upper row to make a copy of it in the shadows indicated in the second row. Together with Emil's animation when rotating the pieces, the shadows help them to determine the correct number of rotations — zero, one, two, or three. However, we should appreciate if they try out — and discuss — four, five or more rotations as well.

The key is to have the pupils understand that to find a solution to the task — without the rotate tool — they would need up to 12 tools to place a piece: four rotations of the blue triangle, four rotations of the red one, and four rotations of the orange triangle.

B4

S: Follow the task in the workbook.
WB: Finish the pattern. For each shadow, write how many times Emil rotated the triangle there.

In this task, the pupils use only one piece, rotating and placing it into a pattern on the stage. At the same time, they mark the number of rotations of each piece that they place. That way, the pupils can think about various rotations of a known shape and gain more experience when working with the rotate tool.

B5

S: Copy the same tree.

The pupils gain more experience when working with the rotate tool.

B6

S: Help Emil copy the top row in the bottom row.

The pupils gain experience when working with the rotate tool when completing coloured circles by assembling them from quarters.

B7

S: This is Emil.

The pupils gain more experience when working with the rotate tool.

B8

S: Mirror the fish. Then complete the task in the workbook.
WB: Draw the outline of each piece in the shadow of the fish. Add the order that you placed them in. Find different solutions.

The pupils' task now is to create a mirror image of the "tangram" fish, noting the order of placement of the individual pieces in the workbook. The pupils will discuss the meaning of the expression "**a different solution to this task**": this includes placing the same pieces in a different order or creating the same shape irrespective of the colour of the individual pieces (meaning that they will complete a large triangle by assembling two halves of it).

Group discussion

(**B1, B2**) *Which of the two tasks was more difficult? Why? Was it difficult to choose the right piece and place it into the pattern? Did you make a mistake at all?*

(**B3**) *Who was able to rotate a piece using the new tool? Did you try to rotate a piece four times? What happened then? Would we be able to complete this task without the rotate tool? How many tools to place a piece would we need in that case? How many times did you actually use the rotate tool when completing this task?* (if the pupils took notes of their solution in the notebook, they just need to count all the rotate signs)

(**B4**, **B5**, **B6**) *How did the rotate tool help us in these tasks?*

(**B7 extension**) *How many different pieces do we need to create and complete the whole sign that says EMIL?*

(**B8**) *Which piece did you place first? Which was the third one? Would you be able to work in such a way that the eye would be placed last? Or in the third position? Did you find different solutions? If yes, how do they differ from each other?*

Emil the Artist • cut-out sheet, pp. V – VI

Cards to rotate

There are two ways to plan the card-cutting in class: either the pupils prepare them after having completed the **B** unit of tasks and start working on the tasks of the **after B** unit of tasks with cards on the table, or they start working on the **after B** unit of tasks

right away, coming back to the cut-out sheet only after deciding, as a group/class, that these cards would help us whilst working on the tasks.

The pupils then cut out the cards (a total of 12), with different images on each side of the card. After the lesson, the pupils should collect the cards in an envelope so that they can work with them during the following classes. We recommend that the teachers laminate the cards first and let the pupils cut them out afterwards — they will become much more durable and much easier to handle.

Emil the Artist • after B • Without computer

Educational objectives

- To strengthen the skills and knowledge acquired whilst completing units of tasks **A** and **B**, namely their skills in guiding Emil, placing the pieces, rotating them and thinking about the order of these operations.
- To think about the appearance of a particular **piece** if it is **rotated** clockwise "once" (i.e. by 90 degrees) and several times. To use paper pieces as a visual aid, which the pupils will cut out of the cardboard sheet attached to the workbook.
- To analyse given patterns and to determine which pieces occur repeatedly in various rotations. To determine the number of pieces that occur in different rotations in a given pattern.
- To analyse given patterns in terms of the **order of overlapping** of the pieces that are placed in it.
- To **read** short records of how Emil placed and rotated the pieces, and to determine the resulting picture.

Computing-specific content

In this unit of tasks, the pupils work with tables to a large extent, both with a **table** that contains individual pieces in different rotations instead of numbers in its cells. From the point of view of computing, an interesting thing to consider is a phenomenon that occurred in the second world as well — the **gradual change of the state of a given position** by e.g. repeatedly watering a position with the grass circle, with a small tree growing out of it, only to later turn into a large tree, blooming and growing fruit with subsequent waterings. Now, we have the basic image of a piece (without a rotation) that changes with every rotation (by 90 degrees clockwise) — it only comes back to its original state after the fourth rotation.

In this unit of tasks, the pupils learn to **analyse a given pattern or picture** on Emil's stage and to study the pieces that were needed for its creation, if we have the ability to rotate each piece. This means that they are looking for the "minimum collection of cards" necessary for them to be able to create the image or pattern.

The pupils deepen their understanding of the **record of steps** taken by Emil — they learn to understand the **notation** of such steps that indicates the commands given to Emil and the order of the commands, along with the order of placement and rotation of every piece. The pupils learn to **read** these records and **execute** them on paper — by drawing them on the small stage. They need to think carefully about Emil's current position, i.e. the position into which Emil will place the next piece, and the fact if it is going to be rotated and the direction in which Emil will be moving next.

Teacher support and commentaries

1

WB: For each piece along the top row of the table draw what it would look like if Emil rotates it once and then a second and third time.
Use paper cut outs to help.

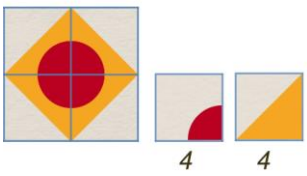
The solution to this task is rather unconventional and demanding: unconventional due to the fact that instead of writing down numbers in the table, we draw pictures — or more precisely, the appearance of each piece from the table header after one, two or three rotations.

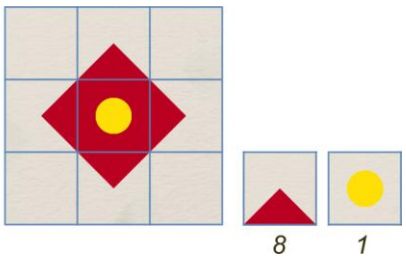
Some of the pupils can complete the task in their head, drawing the resulting shapes of the pieces, others will gladly take advantage of the cards to visualize. They will look for the shape of the necessary piece in their decks (perhaps even in the right colour) and physically rotate it (always by 90 degrees to the right) until they get the rotation they were looking for. Then, they will draw the piece in the table.

2

WB: These two pieces are enough for Emil to make this picture because he can rotate them.
Draw the pieces and how many of them Emil will need to make these pictures:

By now, the pupils will have learnt about the rotation, which is why they are supposed to analyse the pictures now and to determine the (minimum) set of pieces needed to complete each of them — with the help of the rotate tool. A possible solution can be seen below:





3 ***WB: Evert time Emil used a blue circle and a white arrow with the rotate command. You can see four short programs here. Draw a line between each program and matching picture.***

Ahead only!

Each of the four short records starts with the placement of a blue circle that serves as the background to the direction road sign (except for the third shape in the bottom row, which was deliberately chosen as a square and cannot be the result of any of the records). The pupils will thus realize how many times they needed to turn the white up arrow in each assignment — the first needs to go down, the second to the right, the third remains unrotated (i.e. upwards) and the fourth one to the left.

4 ***WB: Emil will use two pieces only with the rotate command and movements in the stage. He will always start in the bottom left. These are his four programs. For each one, draw what he will make.***

In each of the four assignments, the pupils need to carefully execute each step of the record and draw the picture created by Emil in their small 2×2 stages. The first of the assignments is already completed and both of the assignments on the right side are more complicated as they require movement by arrows.

Of course, the pupils may make use of the paper pieces from the cut-out card deck to get help, rotating them on the desks in front of them (this can be done in all tasks of this group and of all the groups that follow).

5 ***WB: Emil is playing with Ludo figures. He only used three pieces and the rotate command to create this picture.***
In the first column you can see how many blue triangles in what rotation he used. Complete the other columns.

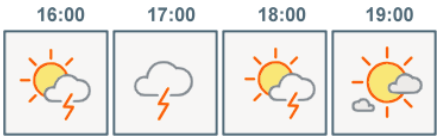
The pupils need to carefully examine (read and analyse) the given picture and identify each occurrence of a certain piece in a certain rotation. It is then interesting to look at the results that the pupils noted in their tables and to compare their outcomes and strategies that they used when completing the task.

6 ***WB: Emil only used two pieces and the rotation command again. These are four short programs and the pictures he created. Draw a line between each program and matching picture.***

An important exercise for reading short programs that make use of rotation. The pupils need to systematically think about the order in which Emil places the green and orange triangles (as they will overlap) and the way in which he will rotate each of them.

The pupils can subsequently examine and further check their solutions in task **X1** in the software.

Group discussion



(task 1) *Have you seen a table that contained pictures instead of numbers?* (perhaps an hourly weather forecast chart etc.) *Did the paper cards help you when working on your solutions?*

(task 2) *Which pieces did you find in the first and the second picture? Can you really create both of them using only two kinds of cards? Who can draw a solution for me on a piece of paper?*

(task 3) *Let's work the other way around now: let's look at the results in the bottom part of page 33 and decide which record can create them… What will be the answer for the third picture below?*

(task 4) *Which of the four assignments will have Emil place wo pieces into the same position?* (in the top-left, bottom-left and bottom-right assignments — even twice)

(task 5) *How many blue triangles did you find in total? How many red semicircles in total? How many pieces did Emil not rotate at all, only placing them? How many pieces did he rotate twice? How many pieces did he place in total?* (there's a total of 18 pieces)

(task 6) *Let's look at the resulting pictures below: Which of the four records created the first picture? What about the last one?*

Emil the Artist • C

Educational objectives

- To work with a given set of basic pieces and the rotate tool, creating own pictures.

- To accurately **duplicate**, using the set of basic pieces and the rotate tool, **a given pattern**.
- To create a **symmetrical image** of a given picture along the vertical axis (a "**mirror**" image).
- To share the resulting image as an **e-mail attachment** to a given address, becoming familiar with the elements of an e-mail message in the process.
- To participate in a class discussion about the **advantages and risks of electronic communication**.
- To create patterns from a set of pieces that span over more than one position and create Escherian-style patterns (see e.g. *https://en.wikipedia.org/wiki/M._C._Escher*).

Computing-specific content

The most important computing concept (or a concept that is related to the pupils' digital literacy) in this unit of tasks is electronic communication via e-mails. The pupils gain practical experience of being able to send their product — on behalf of Emil — to someone else via e-mail. They will learn what an e-mail address (of both the sender and recipient, just like in traditional post) is, along with its format, the receiving person's address, subject line and the possibility to add a (picture) attachment.

We can certainly take advantage of the opportunity to safely send e-mails from *email@robotemil.com* to have a fruitful discussion about the advantages and risks of e-mail communication and the requirements for sending and receiving e-mails, in addition to talking to the rules that prevent us from creating or limit our ability to manipulate our own e-mail addresses etc.

Teacher support and commentaries

In these tasks, the pupils have a fair number of pieces at their disposal and are given a free hand at creating their own pictures and compositions. We can, among other things, organize an in-class competition for the most beautiful building (task C1). We can then collect entries to the competition by letting the pupils send them to the teacher's e-mail address. We recommend that the pupils' computers be online for this activity.

If the teacher does not wish to spend the whole lesson working on these activities, the third task can be skipped. However, we consider the topic of e-mails, attachments and security to be important. Task **C4** (and, to some extent, **C2** as well) also has an interesting connection to the development of mathematical thinking.

C1

S: Build a castle or something similar. Find some ideas in the workbook. Share your creation by e-mail.
WB: Here are some ideas:

After the pupils complete their composition, we demonstrate — and discuss — the process of sharing a picture via e-mail. We discuss the process of typing the sender and recipient e-mail address, the usual format of the subject line (and why it is necessary) and what to write as the body of the message itself. We suggest that the pupils send the pictures to your e-mail address, displaying the inbox on the teacher's computer so that the pupils can see how their e-mails arrive and how we can read and display the attachments.

We also suggest to the pupils that they create and send a picture to their mums and dads (if they know their e-mail addresses).

We recommend that some time is spent discussing on-line security and the places where an e-mail address can be hosted, including the risks related to doing so etc.

C2

S: Copy the teddy bear.

The pupils duplicate the same bear in the white silhouette. Alternatively, they may change the colour of the bear, too. They can then share the resulting idea via e-mail.

C3

S: Build a vehicle. Find some ideas in the workbook. Share your creation by e-mail.
WB: Here are some ideas:

The pupils create a vehicle of their choice from the given pieces. At the end, they can share their creation via e-mail.

C4

S: Animals are looking into the mirror. Finish the reflection.

One by one, the pupils create mirror images of the two animals.

C5

S: Create your own design. Share your creation by e-mail.

One by one, the pupils create mirror images of the two animals.

Group discussion

(about e-mails) *What does it mean to send or receive an e-mail message? What do we usually write in that kind of message? Can we attach our creations to it? What are the advantages and risk of sending messages like that? Who did you share your pictures with? Do you think they will be happy?*

(C1) *Did you use many different pieces? Did you use the rotate tool, too?*

(C2) *Was it difficult to duplicate the shape? Did you create the same bear, or did you change something? How did you make a full orange position — just like the one the bear has over each of his paws?* (we just need to have two large orange quarters of a circle overlap each other, rotating the second one twice)

(C3) *What kind of a vehicle did you make? What did you have most problems with?*

(C4) *What animals are these? Was it difficult to make mirror images of them? Which one was more difficult to make?*

Emil the Artist • D

Educational objectives

- To program a path for the sleeping Emil in such a way that will make him arrive to the target position, eventually completing a certain regular pattern or picture etc. on his way there.
- To become familiar with the "partial" programming method.
- To respect the limited number of positions on the panel whilst planning the solution to the task.

Computing-specific content

In this unit of tasks, Emil is asleep again. Thanks to that, the pupils will immediately recognize that they will have to **plan** his whole path in advance and that they let him **run** the plan, i.e. **program** at the very end. In the programs created by the pupils within these tasks, they will make use of movement commands (arrows) and piece placement commands only; the rotate tool will not be available.

The third world has brought an interesting option and we should probably make the pupils aware of it — they will now be able to **program the solution to the task "in parts"**: we first plan only a couple of steps and wake Emil up afterwards. He will perform all of the commands that he was given, falling asleep at the place to which he arrives. We can then continue in programming further steps and wake Emil up later again. At that point, Emil jumps back to his starting position and executes the whole program again. This approach may be useful if we want to **continuously check** our solutions. Furthermore, this means that we can **re-run the whole program again**.

When programming in the third world, it is, again, possible to **cancel** the last command on the panel by clicking the respective place (and remove another step that becomes the last one, being able to remove commands one by one from the end of the program).

In some tasks, the pupils need to plan Emil's steps carefully because the number of places that are available on the panel is quite limited. In these situations, two things may help them: the fact that groups of commands are stacked and Emil's new "teleportation" ability that moves him to the next row or column. Thanks to that, even a long move in one direction across the stage will only take one place on the panel.

Teacher support and commentaries

Similarly to the previous worlds, the fact that Emil is sleeping signals that the pupils will have to plan — program — in advance, preparing a path that he takes and pieces that he will place along. They may remember the **"turbo" switch** that will speed up the whole action when running Emil's program.

D1 ***S: Plan a walk following the path to the end for Emil. Then wake him up.***

First, we need to check with the pupils that they understand what the path and its objectives are (it is a "path" made of red squares and dark circles — stones, that meanders through the stage to its bottom-left corner. Since the partial planning feature is new here, the pupils might not discover it by themselves. It is up to us to decide when and how we will make them familiar with it. For example, we can decide to plan the first three or four parts on the teacher's computer and then click on Emil. He will run the program that has been created, falling asleep afterwards. We can then continue programming another part of the path and wake Emil up again. We should make the pupils aware of the fact that when waking Emil up for the second time, he will jump back to the starting position and re-run the program from the start. Only then do we let the pairs complete this task and start working on the other tasks.

We have noticed that some pupils do not wish to program the path in parts and rather opt for planning the correct path "in one go". We do not need to force them to use this technique.

D2 ***S: Plan the steps for Emil to finish the pattern. Then wake him up.***

Another task focused on planning and working with a repeating pattern. If the pupils plan the shortest possible journey, they will finish with an empty place on the panel that they can use to move Emil away from the pattern.

D3 ***S: Fill in the missing bits of the caterpillar.***

This task is difficult to plan "in one go", which is in part due to the fact that three arrows are unavailable (it requires careful planning to move Emil from the first line all the way to the third line). This time, programming in parts comes in handy.

D4 ***S: Complete the pattern so that there are three different shapes on each row.***

Mathematically speaking, the solution to this task is simple: the first row needs to be completed with a green square, the second one with a blue circle and the third one with a red triangle. The situation becomes complicated once we factor the computing part into the equation — the path needs to be planned and the number of free places on the panel is quite limiting. That said, there are several solutions to this task, but it is never possible for a movement to the next empty position to occupy more than one position.

D5 ***S: Finish the train, fill in the white areas.***

The picture of a locomotive is almost finished, and the pupils only need to program a path for Emil in such a way that he fills in all of the white parts. That means that this task is, again, focused on the planning of movement and piece placement.

D6 ***S: Build a program so Emil will copy the same stars until the end of the row.***

Another task focused on working with a regular repeating pattern that needs to be completed by the pupils.

When the pupils prepare and run the program, correctly filling in the remaining part of the pattern, it is a good idea to discuss what parts repeat and in what manner they do so. Similarly to the repeating groups of double and triple cards in the second world, this world also presents us with an opportunity to create the whole panel by two sets of triple steps here: *place a large blue star, place a small blue star and move right, place large orange star, place small blue star and move right.* If we were able to mark these trios of steps in some way, the whole program to complete the pattern would be really simple.

Group discussion

(for the whole unit of tasks) *How come that we immediately realised that we are going to plan Emil's journey ahead of time?*

(D1) *How many steps in total does Emil need to take in order to reach the final position?* (24 steps) *Did you let Emil walk in parts when you still had an unfinished part of the program?*

(D2) *When the pattern's complete, what are the two kinds of positions that repeat? If Emil were to create the whole pattern, what steps would we need for him to take so that he creates the first position in the pattern?* (place a black square, place a yellow circle on top of it and move right) *And how would he make the next position?*

(D3) *How did you know the exact pieces that Emil needed to place, say, in the position in the third row of the third column?* (we examine the repetition of the colours around and "calculate" it) *In which row and column does the centipede have its first "turn" and where is the second one?*

(D4) *Did you have enough places on the panel? Which arrows did you use? Would you be able to make Emil get back to his original position at the end of the program?* (no, we need all five places to complete the task — we place a piece three times and move along the stage twice)

(D6) *How many free spots do you have left on the panel? Would you be able to navigate Emil back to his starting position? What steps do we need to create a position with a large and a small blue star?* (*place a large blue star, place a small blue star*, and, eventually, *move right*) *What steps do we need to create a position with a large orange and a small blue star?*

Emil the Artist • after D • Without computer

Educational objectives

- To strengthen the knowledge and skills acquired by the pupils when creating programs for Emil that contain steps and piece placement (without rotations).
- To read and execute given programs for Emil on paper, to draw Emil's creations in the workbook.
- Based on the instructions or the resulting picture that Emil has to create, to read an incomplete program and fill in the blanks.
- Based on the resulting picture that is to be created, to find a mistake in a program and mark it.

Computing-specific content

In all tasks of this group, the pupils focus on the **reading and execution of a program** (which, at the moment, does not include the rotation of the pieces that have been placed). It is an important skill and part of computing-specific thinking patterns: the pupils need to read the program step by step, drawing Emil's movement and piece placement in the workbook They need to realise the **starting** position of Emil on the stage and his exact position after each command of the program.

Another important and complex computing skill is to examine the relationship between a given program — which might **not be complete** or **flawless** —and the resulting picture that is supposed to be created. The pupils learn to examine this relationship in both directions: If the given resulting picture is correct (or it is otherwise clear what Emil needs to create) but the program is not complete or correct, the pupils **run and compare** the program with the expected results step by step.

This type of **work with programs** is an important part of computing-related thinking by itself, but at the same time, it prepares the pupils for working with memories, which represent the main objective of units of tasks **F**, **G** and **H** (i.e. preparation for the concept of procedures that will emerge later on).

Teacher support and commentaries

A key component of this unit of tasks is reading and completion of Emil's programs. Given the new constructions that the pupils will discover in the second part of this world, we need to pay attention to pupils that should carefully read a (short) program step by step and (perhaps in their heads) remind themselves: Where is Emil standing right now? Will he first place a piece, or will he move? If he places a piece and places another one in the next step, where exactly will he place the second piece? **(in the same position)** If he placed a piece and moved, where is he now? If he is to place a piece again, where exactly will he place it?

WB: For each task draw in the stage what Emil will create if he runs this program.

The pupils will now be presented with seven programs that the need to read carefully — step by step — and subsequently run it, drawing Emil's path and the placement of pieces (still without rotations). At this point, it is important to be aware of the fact whether the pieces that are placed will land in the same position or whether Emil moves elsewhere in the meantime.

In the fifth assignment (in the middle of the right column), Emil places the red triangle, taking the "long way" to the same position, placing another triangle, this time in green. Let us also notice that in the last, seventh assignment, Emil places a small red circle after moving right and up, and immediately after that, he places a large blue circle that will fully cover the small one. We would appreciate if the pupils made comments about this "oddity" by themselves.

WB: Emil starts on the left side to run this program. What will he write down?
Write in the stage:

We expect the pupils to figure out that a place on the panel (actually, a command) that looks like a letter means that Emil will write this letter on his current position. The pupils carefully run the program and write down the positions of new letters in their workbooks.

WB: Now Emil starts from a different position and he needs to write HEY EMIL in the stage with this program. Fill in the blanks to complete it:

Similar concept, reverse task: The pupils will write down the result of a given incomplete program in the resulting stage. Then, they will proceed step by step, carefully reading the program and writing down the letters that Emil needs to write in certain positions.

The instructions indicate that there needs to be a blank space between the words **HEY** and **EMIL**.

WB: Emil needs to complete the two overlapping squares. Fill in the blanks in his program.

Now, the pupils need to figure out the look of the resulting stage – a smaller and a bigger square overlapping each other. They may also draw them in their workbook with a pencil to make it easier to fill in the missing parts in the program. Some complications might arise due to the fact that the empty place where the squares should overlap needs to be occupied by two "corners", which will resemble a "cross" of both lines.

WB: There is an error in the program. Find it and circle it.

The pupils carefully read the program and run it in the picture in their workbooks. That way, they will find out the incorrect step.

Group discussion

(task 1) *How many positions did he place pieces in — in the first, second, third assignment...? What exactly will we see in each of the small stages?*

(task 2) *What word will Emil write on the stage? Will there be an empty position left somewhere?*

(task 3) *Which letter will Emil place as the last one? Which will be the second one?*

(task 4) *Did you come up with a solution to this task? Will Emil use any piece more than once? Which one? How many times?*

(task 3) *Is there really an error in the program? Would you be able to correct it?*

Emil the Artist • E

Educational objectives

- To **plan a solution of the whole task** for the sleeping Emil, this time including the **rotation of pieces**.
- To **read** (short) programs with arrows and pieces with rotations and to **determine** the appearance of the resulting picture.

- To **think about the order** of placement of overlapping pieces whilst programming.
- Based on a given picture, to plan a program that will navigate Emil through its creation or completion.
- To consider various solutions — programs — that will make Emil create the same picture.

Computing-specific content

Now, the pupils will be able to use the **rotate tool** in their programs as well. They will not only plan such programs, but also **read** them from the workbook and **run** them, either in their heads, on paper or on the computer, to either **realize**, **draw** or **check** what the result will look like.

When planning programs with rotations, the pupils might make use of the **cut-out cards** to help themselves. The work with cards is important in their development as well, being especially helpful when developing mathematical thinking that involves the **recognition of shapes and their rotation, symmetry** etc.

In several tasks of this group, the pupils need to plan the **placement and rotation of two pieces that overlap in the same position.** Therefore, they need to think about the **order** of their placement in addition to the choice of the individual pieces (or their colour).

In task **E7**, we ask the pupils to program two different solutions (although there are even more). The solutions may differ in their paths (the order in which he walks past the positions) or by the use of pieces in varying positions.

A note on the corrections of errors in programs: The pupils already know that they can cancel the last command of the program by clicking on it. This means that a stack with a repeating arrow will be reduced by one occurrence of the command after each click, leading to the complete removal of the arrow at the end. The same is true for rotations as well. If we planned a number of rotations (one, two or three), each cancellation of the last command will remove one mark from the program.

Teacher support and commentaries

E1

S: Build a program so that Emil will finish the pattern.

The first tack focused on the planning of solutions with arrows, piece placement (only one piece in this task) and their rotation. We recommend that the pupils use the cut-out cards as aids when completing these tasks if they wish to do so.

E2

S: Follow the task in the workbook.
WB: Read this program and draw what will happen when Emil runs it.
Then check your solution on the computer.

The pupils need to read the given program and subsequently run it in their workbooks (by drawing the changes on the stage in their workbooks). Only then do they program the path for Emil on the stage and run it.

E3

S: Emil needs to complete the balls with the black pieces. Then finish the task in the workbook.
WB: Which of these programs creates which ball? Connect matching pairs with lines.

Another task focused on the planning of a solution that includes the rotation of cards. In the extension of the task, they need to carefully read each of the short programs and determine the pictures that result from these programs.

E4

S: Finish the snail and get back.

The pupils have completed similar tasks before, e.g. in unit **C**; however, they did not need to plan their solutions ahead of time.

E5

S: Follow the task in the workbook.
WB: Program Emil to create the pictures.

For each ball, write your program here.

Although this task is similar to task **E3**, the pieces now **overlap**. The pupils thus need to think carefully about which piece is in the bottom position and which piece is above it, i.e. the order of individual pieces — and their rotation.

This time, we disregard Emil's movement using the arrow tools when writing down their programs in the workbook. For each "special ball" they only need to draw two steps: the piece and its rotation, and another piece and its rotation.

E6

S: Follow the task in the workbook.
WB: With Emil, create this dog. Then get Emil back.

We will find the picture of dog to copy in the workbook. It will help the pupils to plan the pieces and the rotations that they will need to complete it. Again, this task lets the pupils practice their planning with rotations. The pupils will certainly appreciate having the cut-out cards to help them.

E7

S: Follow the task in the workbook.
WB: Emil needs to create a big triangle. Program two different solutions and write them here:

The solutions may differ in the order that Emil walks past the stage placing the pieces, or in the way in which Emil assembles the red square — there is a choice between whether he does that in one step or in two, assembling it from two triangles.

Group discussion

(**E1**) *How long was the program that you created? Was there a free place left for taking Emil back to where he started?*

(about rotating pieces) *How do you proceed when planning how to rotate a piece? Do you use paper cards with pictures? Do they help you?*

(**E5**) *How do you know which piece Emil should place first and which should go second? Does it matter? Does it matter always or only sometimes?* (only when the pieces partially overlap. For example, in task **E3**, it does not matter at all because both semi-circles are always suitably rotated.) *How many pieces is the first object made of? What about the last one?* (we always need only two pieces but there may be another semicircle behind the one on top, either in the same colour or in a different one)

(**E7**) *Did you find two different solutions? How are they different?* (the order of movement and piece placement; the way we created a square in the bottom left corner)

Emil the Artist • after E • Without computer

Educational objectives

- To strengthen the knowledge and skills acquired by the pupils when creating programs for Emil that contain steps and piece placement (with and without rotations).
- To read and execute given programs for Emil on paper, to **think about their features** and to determine the picture which they will create.
- To complete a program with the **missing numbers of rotations.**
- To plan Emil's path, placement of pieces and rotations on paper win such a way that they create a prescribed image.

Computing-specific content

The tasks in this group are focused on **reading, running and completing** programs for Emil that contain arrows, placement o of pieces and their rotation.

The work with programs is a major part of reaching understanding of the basics of programming and algorithmic thinking. Our emphasis is placed on **reading, thinking about and examining the features** of programs (in task **after E2**, for example, they count the total number of uses of the rotate tool in the program), **running** them on paper or in their heads to determine the resulting picture, to **complete the programs** with the missing numbers of rotations of pieces that are placed by Emil, or to **plan** the whole program that will complete an unfinished picture **on paper**.

We lead the pupils to see the program — their own or the programs of other pupils in the class —as the focal point of programming (and one of key concepts of computing per se), as an expression of their thought, approach or strategy. We naturally want to solve the problem. At the same time, though, we are also learning to write down, express, share, improve, compare and edit our solutions, among many other things.

Teacher support and commentaries

1

WB: Which ball will Emil make with this program?

This is a more complicated variant of tasks **E3** and **E5**, because now, we assemble the resulting "ball" from three pieces, with each of them being rotated differently. The pupils read the program and think about which of the four images it will create. It would be appreciated if the pupils in discussion commented on the fact that rotating an image three times to the right is the same as rotating it just once, but to the left.

2

WB: How many times did Emil use the rotate command on this piece in this picture?

Emil used the rotate command ... times.

Emil created the airscrew from the same piece in four steps: he used one unrotated piece, one that was rotated only once etc. Therefore, he used the rotate tool for six times in total.

3

WB: Follow the program. Rotate the 'Ahead Only' signs to match the next direction of travel, then write this down on the sign.

Draw Emil's path, where he placed the signs and which way they face.

The pupils carefully read the program: at each road sign, they think about which way Emil will go next from his current position — we find out thanks to the next arrow. Then, they "rotate" the road sign accordingly to make it point in the direction of the next part of his path. They also continue drawing their path on the stage in their workbooks using a pencil.

4

WB: Below, write a program that will draw two missing curious fish. You can use the movements, these pieces and the rotate command:

> The shadow always indicates the appearance of the fish in a given position. The pupils need to carefully plan each step, the order of placement for pieces and their rotation. If they proceed carefully, they will be able to plan the whole task in 10 steps.

Group discussion

(task 1) *Now, we will work this way: Let's take a look at the first step of the program and strike out the pictures that don't look that way. Which ones will they be?* (only the first picture) *If we imagine the appearance of the second piece after three rotations, which pictures can we exclude?* (the second and the fourth one) *Is the third picture the right answer then? Does the position of the third piece fit, too?*

(task 2) *Let's look at the resulting airscrew: where is a piece that Emil did not rotate at all? Where is a piece that he rotated once? What about one that he rotated twice…?*

(task3) *We need to rotate the first road sign once. Is that true? How do we know? Where would the second road sign stand on the second stage and what direction should it point in?* (below because Emil will continue downwards from this position)

(task 4) *Did you make the whole program? How many places were there left on the panel?* (certainly not more than two)

Emil the Artist • cut-out sheet, p. III and bottom part of p. IX

Envelopes for memory cards, memories

This serves as preparation for tasks with memories, i.e. mainly for the **before F** unit of tasks. From p. III, the pupils will cut out four simple "envelopes" for "memory cards" — with our pupils, we will call them the "green memory envelope" "red memory envelope", "violet memory envelope" and "blue memory envelope". According to the instructions in the bottom right part, they will fold and tape the memories so that they can stick in a memory card of the corresponding colour.

The pupils will also cut out four green and four red memories (in the bottom part of p. III — we will use them in task **before F1**) along with two violet and two blue memories (we will use them in task **before F2**).

Computing-specific content of the game

This time, it is not a game but a preparatory task for the tasks of the **before F** unit of tasks (preparing for the work on solutions in the **F** unit of tasks). We will explain the computing-specific content of units of tasks **before F**, **F** and **after F** in the respective parts of this teacher's resource.

Emil the Artist • before F • Without computer

Educational objectives

- To become familiar with the term **memory** and with the fact that we can **mark a set of commands** for Emil by a coloured sign (in the form of a small memory card).
- To understand that these signs may appear in Emil's program as special steps that r**epresent the corresponding group of commands**.
- To learn how to **run Emil's program** that includes (i.e. uses) the sign of a memory.

Computing-specific content

Motivation: It was back in the first world that we encountered the **limitation of the number of steps** — for example, in task **G1**, we were supposed to collect as many pears as possible in only three clicks (although we might have needed a total of four clicks to be efficient). Similarly, a step or two more would come in handy in task **G3** so that we would be able to collect all four pairs of the same letters. This was the first serious limitation in the number of steps that we needed to be careful about. In the second world, we found a similar limitation, this time demonstrated as the **number of places on the panel**. That was the reason why some of the tasks were impossible to complete (e.g. **A3**). In the **B** unit of tasks — and in all subsequent units of tasks — we discovered and started using a simple phenomenon that allowed us to squeeze more steps into the panel, namely **the stacks of repeating commands**. Later, an even more helpful aid (starting with unit **G**) was the ability to combine two (and later more) commands in one **double card** (later also triple and quad cards). If these "double steps" repeat immediately after one another when completing the task, they will form **stacks of double cards** that **keep more free places on the panel**. At that time, we considered a situation when there is a pair of commands that appears twice or three times in a program, **but not right after each other** — in that case, the pairs could not stack (e.g. in tasks **after F2** or **after F3**).

In the third world, we are coming back to a similar phenomenon and we will learn to use a similar solution that is even more powerful — **Emil's memories**. With the pupils, we will discuss the aforementioned limitations in the number of steps a program can have and say that Emil can learn a number of steps and remember them, say, in the green or red memory. In two tasks of this group, we will learn to **run programs (on paper) that, in addition to arrows, use the green and red memories** (task **before F1**) or the blue and violet memories (task **before F2**).

Teacher support and commentaries

WB: *1. Cut out all red and green memories.*
2. Pick one green and red at random and swap with your neighbour.
3. Read the program with your green and red memories and draw in the stage what Emil will create.
4. Play again with different memories.

In this task, the workbook gives us only one program with arrows and signs of the green and red memories. However, the task comes with four assignments — the pupils will run the same program in their workbooks, but **the content of the red and green memories will differ**.

Each pupil will receive one green envelope with a randomly chosen green memory and a red envelope with one of the red memories. We will talk about how we were sometimes limited by the number of clicks in the first world, about the limitations in the number of places on the panel in the second world, and about the fact that we will learn about Emil's new capabilities now (although the number of places will still be limiting, it will somehow inflate). This is because Emil can now **keep several steps of the program in the green memory, save other steps in the red memory** and then run a program that, in addition to common commands, contains **special commands: the sign of a green memory** that says *"take the steps you keep in the green memory"* and the **sign of a red memory** that says *"take the steps you keep in the red memory"*.

Therefore, the task is to draw Emil's **exact** creation on the stage for the given program and the content of the green and red envelopes. For the first assignment, this might mean: Emil starts in the leftmost position, takes one step to the right. At the second position, he **runs the steps from the green memory** (which are different for each pupil), takes another step to the right, runs the steps from the red memory etc.

In some situations, it has proven helpful to work on the first assignment with the whole group together and only then to work separately in pairs. For the next assignment, the pupils come to the teacher to replace the content of the green envelope with a randomly selected green memory and the content of the red envelope with another randomly chosen red memory. The paper envelopes only serve to preserve the symbolism: the green envelope has an icon of the green memory, the red one has the red memory. When the pupils create the mental link, we do not need to continue using the envelopes and it is enough to take a card with the content of the green and red memories.

Possible problems: some pupils were confused by the white dots on the memory symbols (one on the green memory, two on the red memory etc.) — we've met with a mistaken interpretation that one dot means "repeat once", two dots mean "repeat twice" etc. We need to emphasize to the pupils that the dots are only there to make the difference between the memories clearer.

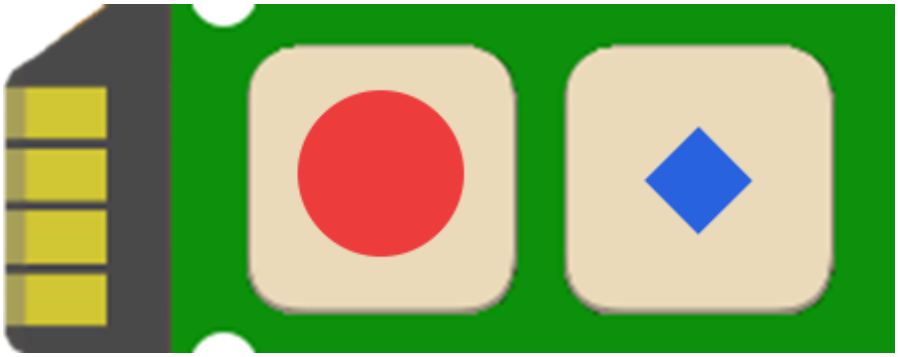
Sometimes it also happened that the pupil flipped the memory (see bottom right) and mistook the order of commands. The correct rotation of the memory can be seen on the left side:

yes no

WB: *1. Cut out all blue and violet memories.*
2. Do the same as last time using blue and violet memories.

The difference between the previous memories and those which the pupils will use in this task lies in the number of steps and the fact that now, there are arrows among the steps that Emil remembers. The common program in the workbook also contains several movements for Emil, which means that the pupils will draw the resulting pictures on larger stages with four columns and three rows. When running the programs with blue and violet memories, they will need to be even more careful than before and — at each command of the program on the panel or in the memory — carefully answer the question: *Where is Emil now? If there is an arrow, where will he move? If the placing of a piece follows, where exactly will he place it? Will he then move elsewhere, or will he stay in the same position? Will he place the next piece on the previous one?*

If you think it might be useful, print a large memory like this to use as an illustrative example for discussions with pupils during this and the next activity.



Group discussion

(task 1) *What happens when Emil encounters the **sign of a green memory** when running the program on the panel? What if it is the **sign of a red memory**? For the rest of us, read carefully and tell us what exactly Emil does when he is supposed to run the green memory. Read the red memory for the others as well. How many times will Emil run the green memory in this program? How many times will he run the red memory?*

(task 2) *How many times will Emil run the blue memory in this program? What about the violet one? For the rest of us, read carefully and tell us what exactly Emil does when he is supposed to run the blue memory. Read the violet memory for the others as well.*

Emil the Artist • F

Educational objectives

- To learn to **read and accurately execute a memory** (green only, or both green and red).
- To gain first experience running a program with a ready-made ("learned") memory (one or two.
- To learn to see the program as a record on the panel **together with the content of the memories** (if their icons appear on the panel).
- To use memories and piece placement commands on the panel in such a way that Emil will create a repeating pattern.

Computing-specific content

Given that the pupils will **explore and use a new and demanding computing concept**, Emil is awake again. This is because it will be easier for the pupils to explore the concept when they can navigate Emil directly using arrows, piece placement commands and the red and/or green memory commands. That way, they receive immediate response after each step, seeing what Emil does.

In these tasks, the pupils learn to **work with pre-made memories**, first only with the green memory, later adding the red one as well. At this point, they do not program the whole solution to a program for Emil yet, but **control him directly**, either by choosing one of the movement arrows, the piece placement command or the green or red memory. We want them to realise that the memories represent another means to **save the number of steps taken by the program**, and a very powerful one at that. In fact, this is a set of several steps that will be repeated when completing the task for a number of times (as a propaedeutic approach to the concept of **procedures**). We have actually **"labelled"** the short progression of commands by the sign of a green or red memory and from now on, we use the symbol of a new command as the "name" or a representative sign for a whole set of commands.

We can already see in the first task that Emil would only be able to fill in four positions on the stage if he did not have the green memory. However, if he uses the memory, he can use one "green step" to fill in the whole position and the panel will allow him to fill in several other positions.

Let us also notice that no memory in the first four tasks contains an arrow — they only contain the commands to place two or three pieces into the same position, usually with overlapping as well.

In tasks **F5** to **F8**, the memories contain one or more arrows. For the pupils to complete such tasks, they need to learn to carefully "read" the effect of running a memory on Emil's actions. In some cases, the pupils need to complete the picture created by Emil when running the memory by placing an additional piece (task **F5**).

At the end of task **F8**, the pupils write down the number of commands that they used into a table. However, the task contains another important shift: as a group, we need to clarify the way in which we will count the number of commands (arrows) that are used in the description of a memory.

Teacher support and commentaries

F1

S: Use Emil to make as many identical patterns as possible.

The pupils can assemble the same patterns by creating them from two triangles on each position (the bottom left solution). However, they will only manage to fill in four more positions that way. On the other hand, Emil can complete

a whole position by using the green memory as well. Therefore, instead of taking two steps with triangles, we can use the green memory and move to the adjacent position to the right (the bottom right solution):

It would be interesting to navigate the pupils in the final discussion to think about how the task would become easier if the memory contained an arrow command to move Emil right in addition to the placement of two pieces.

F2

S: Use memories to complete a row of houses and trees. Then fill in the table in the workbook.
WB: Complete the table: How many times did Emil use the red and green memories in his program?

As the unfinished picture on the stage indicates, the pupils are supposed to finish the top parts of the spruce trees (above each trunk that is already placed there), which is exactly what **Emil does in the green memory**, and to finish the bottom parts of the houses (below each red roof), which is exactly what he **does in the red memory.**

The record of the commands on the panel will be shorter if we always move Emil using only one arrow and make use of the teleportation feature.

F3

S: Get Emil to finish the African textile pattern.

The pupils should read and examine the effects of the green and red memories — and try that out as well. Then, they navigate Emil to create or complete the same pattern on the whole stage (including the first row).

F4

S: Follow the task in the workbook.
WB: Now create this African pattern with Emil. Make sure that it is exactly the same as this picture.

A pattern that is similar to the previous task, but it is prescribed as a picture in the workbook. The pupils need to analyse the pattern, examine the given memories and copy the same pattern on the panel. The number of places in the record of the steps on the panel is not limited in this task. However, a new option — and need — has appeared for creating the pattern: the use of the rotate tool.

F5

S: Plant the flowers as seen in the workbook. Then finish the task in the workbook.
WB: Now we have a new memory:
Draw the flower Emil will make using it.

For the pupils to complete the first part of task **F5** (in the software), they need to carefully "read" the effects of the green memory from the screen to realize where Emil will finish after running it. Only that allows them to correctly copy the flowerbed from their workbooks. However, it can also be done by making Emil run the green memory and watch him work. We can then cancel the record on the panel afterwards and start planning the places where Emil will run the green memory so that it fits the picture in the workbook. However, we need to add a yellow circle to each flower and move Emil to the position of the next flower using arrows. Let us also notice that this is the first time that **a memory also contains a movement arrow**.

The workbook extension to the task provides different content in the green memory to the pupils: they first need to read the green memory in the workbook and draw the resulting flower into the small 2×2 panel.

F6

S: Finish the pattern.

In this task, the example pattern is indicated on Emil's stage. Both memories contain arrows — the first one even contains a stack of two arrows. The pupils learn to rea the content of the memories, think about it and intentionally use the memories to complete the pattern.

F7

S: Finish the pattern as seen in the workbook.
WB: The pattern you need to complete with Emil:

This time, the resulting pattern is specified in the workbook and both memories contain an arrow. The pupils first need to carefully examine and test the content of the memories and only then can they move on to thinking about Emil's steps. In this task, it is not necessary (and possible) to rotate the pieces.

F8

S: Help Emil finish both rows of houses. Then fill in the table in the workbook.
WB: Complete the table:

Find another solution and write it down:

By reading, discussing and exploring, the pupils should realize that the green memory makes Emil **build a blue house and move right** and the red memory makes Emil **build and orange house and move right**. Then they start working on the first row of houses and notice that if they build houses of the same colour next to each other, the signs of **memories will stack in the familiar way**. That way, the whole first row of houses will occupy very few spaces on the panel.

If they use teleportation to move to the beginning of the second row of houses (i.e. move between the rows by moving in one direction to the end), they can complete the whole scenery using only four places on the panel. We could also colour the houses in a **partially alternating pattern**.

However, we continue with an interesting extension: to count the number of the **green memory** commands (there are three in the left solution), the number of the **red memory** commands (there are 5 in the left solution); there are zero up and down arrows, but what about the right arrows? Do we only count the ones we see on the panel, i.e. 1 + 12? Or do we add the 3 that were used with the green memory and the 5 that we used with the red memory?

These are good and important questions and should open up a discussion regarding what the **program** or **the record of the solution** is here. Does it only involve the steps on the panel, or does it also include the steps in the memories? It is a great achievement only to ask these questions in terms of computing because they signalize that our thinking goes in the right direction.

Of course, the **complete record of Emil's steps (solution of the task) includes the panel together with the memories** — otherwise, we would not be able to read what happened. When completing this task, we used the right arrow 1 + 12 + 3 + 5 = 21 times in total.

Group discussion

(whole group) *Do we program Emil's future behaviour here or not? Do we navigate him directly to make him perform our commands?* (yes, and we realize that immediately because Emil is not sleeping but listens to us and obeys us

(F1) *How many positions on the stage did you manage to fill? Did you use the green memory? Is it really necessary? Why should we use it?*

(F2) *What exactly does the green memory do? How did you find out? What about the red one? How did you know where to complete a house and where to complete a tree?*

(F3, F4) *Did you successfully make African patterns on the whole stage? What was the most difficult thing about it?*

(F5) *What would Emil create if we first placed a yellow circle somewhere in the middle of the stage and then moved down by a position with Emil to run his green memory there? What would the flowers look like if we used the version of the green memory from the workbook?*

(F6) *Can Emil keep a stack of arrows in his memory? What will these green and red memories do?*

(F8) *Did you "build" the eight houses successfully? How many empty places remained on the panel? How many times did you use the green and red memories? How many times did you use the right arrow? How did you count it?*

Emil the Artist • after F • Without computer

Educational objectives

- To deepen the understanding of how to **work with Emil's memories** and develop skills related to their **use**.
- To learn how to **read** a given memory and **deduce** the result on the stage if the memory is used repeatedly.
- To know how to work with a memory whose arrows will make Emil teleport between rows or columns.
- To realize that if a memory with certain content is used by three different programs on the panel, three different pictures will be created.
- To realize that if we run a program repeatedly but replace the content of the memories at each run, we will create different pictures.

Computing-specific content

In the tasks of this group, we focus on the reading and running programs (in the head or on paper) that **use one or more memories** that serve as a **label for a short group of commands** that allows it to be reused, either in direct succession and stacked, or with other commands that separate some of the uses of the memory. Here are two illustrative examples of such programs:

The pupils need to realize that this kind of program on the panel — be it the one in the top left part or the top right part — can be run only if we know what group of commands is represented by the green memory. If we ran one of the programs twice but used a different content of the green memory (a different group of commands) at each run, we would most probably create two different pictures on the stage.

In addition to the preparation for the concept of **procedures** (or **commands** or **own blocks** in Scratch etc.), the pupils also learn how to carefully and systematically run programs on the panel and realize at the right time what commands are represented by each use of the corresponding memory.

Teacher support and commentaries

1

WB: Draw in the stage what Emil will create if he runs this program with the green memory:

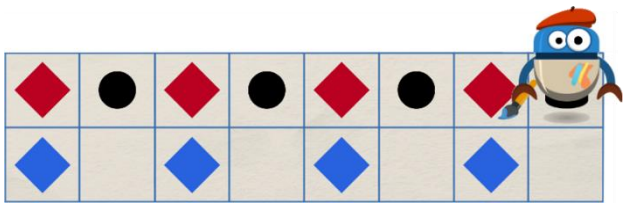
A task focused on reading and interpreting a program with a memory. The pupils need to proceed very carefully because both the program on the panel and the green memory place a black circle into the stage. This will result in a row of six circles (right to left): black, black, red, black, black, red.

The pupils can subsequently examine and further check their solutions in task **X4** in the software.

2

WB: Draw in the stage what Emil will create if he runs this program with the green memory. Mark where he will finish.

A similar task, but this time, the content of the green memory creates a column of pieced and teleports Emil to the next column.



The pupils can subsequently examine and further check their solutions in task **X5** in the software.

3

WB: Emil puts the pieces in the stage with the green memory and moves to another position with the red memory.
Emil's star position is number 1. Read the whole program and number the positions as Emil creates them.

In this task, the pupils are to read and run a program with two memories, of which one places two pieces (*How will it place them? On top of each other because there is no movement between the commands*) and the other navigates Emil down and right. The aim is to run the program step by step and number the white circles in the picture in the workbook according to the order in which they are created. The resulting numbers will be 1, 3 and 5 in the top row, and 6, 2 and 4 in the bottom row.

4

WB: We have made this violet memory for Emil and three different programs that use it.
In each empty stage, draw what exactly Emil will create when he runs these programs using the same memory.

In this task, the pupils should read, run and draw the resulting picture for three different programs that use the same violet memory. Since the programs are different, different pictures are created, even though they make use of the same memory.

5

WB: Emil started in the upper left corner of his stage and ran this program:
If green memory looked like A, which picture would Emil make? Draw a line between them.
Do the same for B and C.

This is a reverse situation: the pupils read a single program with a memory and should determine the resulting creation — however, with varying contents of the green memory. Their task is to draw a line between the memory and the resulting picture. We want the pupils to realize that (a) a program with a memory cannot be run until we know exactly what the memory does, and (v) different contents of memories lead to different resulting pictures.

Group discussion

(task 1) *Let's read Emil's actions step by step. What is his first step?* (placing a black circle into his position) *What is the second one?* (move left) *What is the third one?* (uses the commands in the green memory, placing a black dot into his position) *What is the fourth one?* (continues in the green memory, moving left)...

(task 2) *Let's read Emil's actions step by step.*

(task 3) *Let's read the program. What will the first use of the green memory do?* (places a large blue and small orange square into the top left position) *What will the use of the red memory do?* (navigates Emil by a step down and a step right) *What will the next use of the green memory do?* (places the same pattern made of two squares in this position) *Where will Emil move using the up arrow?*

(task 4) *What will a single use of the violet memory make on the stage?* (a tree) *Where will Emil finish?* (in his starting position) *How many trees will program **B** make? How will they be ordered? What about program **C**?*

(task 5) *Where will Emil finish after running memory **A** once? Where will he finish after running memory **B** once? What about memory **C**?*

Emil the Artist • G

Educational objectives

- To use pre-made memories when **planning** a complete solution to a task for the sleeping Emil.
- To realise how significantly memories can **shorten a program** to solve the whole task if they include navigation arrows in addition to placing pieces.
- To remember that Emil can be programmed in parts and to gain more experience in this regard.
- To use the **rotate tool** when planning steps so that Emil places the pieces correctly.

Computing-specific content

This is the first group of tasks in the third world where the pupils will **create a program** for the sleeping Emil in advance and **use one or two pre-made memories**. Their task will thus be to (a) understand what the memory or memories in the given task do, and (b) come up with a way to solve a given problem using such "shortcuts", i.e. small groups of commands. At the same time, they can:

- program Emil **in parts** — by gradually adding parts of the program and subsequently waking Emil up to run the whole program and help us check whether we are proceeding correctly;
- to examine and experiment with commands, e.g. memories, meaning that we can decide to add the green memory command only and then wake Emil up — this can help them to check the hypothesis about what the green memory does, even if the resulting program is not supposed to begin like that. This allows them to check the commands and cancel them on the panel right afterwards.

The first two tasks should raise the pupils' awareness of the fact that if **memories contain Emil's movement** using arrow tool(s), they can significantly **shorten the whole resulting program**. The subsequent tasks then require careful **planning** that sometimes includes the rotation of a piece. The assignment of the fifth task consists of **textual instructions** in the workbook that navigate the pupils through the programming of a rather complex African textile pattern. In the final task of this group, the pupils need to first understand how a picture of a small ship can be combined from two memories and some additional commands. The pupils need to examine **where Emil will move after running each of the memories**, realizing **what** needs to be done next and **where** that should happen.

Teacher support and commentaries

G1

S: Finish the red and green rows of macaws.

In this task, both memories stand for a simple placement of a parrot — a green and a red one. The pupils plan the path and complete a task that is similar to the previous ones; this time, instead of using a tool to place one or another piece (this time, a parrot), they use memories.

It would be great if the pupils realized that the memory could include a right arrow (i.e. navigation) in both cases. That would make the program significantly simpler and shorter (which is precisely the aim of the following task). After all, that is what the memories should serve for — to label useful groups of Emil's steps (commands) that come in handy repeatedly by the sign of a memory so that we can reuse it in the program as a shortcut.

G2

S: Follow the task in the workbook.
WB: Add missing macaws again and write down your program:

This task is almost identical to the previous one, with a small difference — in addition to placing a parrot, Emil keeps the navigation to the right in his memories as well. This means that the whole program will become shorter: either by just a couple of steps (if we take the "traditional" approach) or significantly, if we decide that Emil places parrots into the positions where there already are some (see the two possible solutions below).

Whatever the approach, there are two empty spaces next to each other in the row of red parrots (only marked by shadows) and the pupils naturally use the red memories after each other, seeing that even the sign of a memory as a command will be stacked.

G3

S: Use Emil to copy the school bus from the workbook.
WB: A picture of a school bus:

Using the example picture of a bus in the workbook and the two pre-made memories, the pupils carefully plan the same picture on the stage. The **method of programming in parts and repeatedly checking the program** may be very useful here. At the beginning, the pupils can try out the memories by creating single-step programs that only contain the signs of memories and let Emil run them. That way, they check what each of the memories does, cancel the program and start over.

G4

S: Use Emil to fill in all the blanks.

This task is similar to **G3**, but the pre-made memory contains several steps with two movement commands, which means it is more difficult to understand.

G5

S: Follow the task in the workbook.
WB: You can also create the program in parts. Follow these steps:
1. First, use the green memory five times.
2. Wake Emil up and find out what he does and where exactly he finishes.
3. Do not delete the program, but continue creating it. Use the red memory to add dots to all blue squares.

This task directly asks the pupils to program in parts. In the workbook, they receive three text-based instructions that need to be performed one after another. First, they use the green memory for five times, seeing that the commands group in one stack, and then they run the program. That way, they see the results on the stage along with Emil's final position. Then, they continue programming using the red memory. They add four red memory commands — to get four orange dots in the blue squares in the bottom part.
They re-run the program to make sure they proceed correctly and to find out where Emil will land after teleportation. They will complete the picture using the right arrow and four more red memories (they can also move Emil away from the pattern by using one extra right arrow).

G6

S: Finish the African pattern using the green memory.

This is a similar task that trains careful and gradual completion of the unfinished African pattern.

G7

S: Help Emil copy the boat two more times. Then complete the task in the workbook.
WB: Which of these programs will draw exactly the boat we need?
Yes *No*

Now, both memories help complete one complex picture — a small sailboat. However, the pupils need to carefully explore the possible combinations of the memories, to move Emil between the individual steps (if necessary) and when to add the red rectangle to make the middle part of the ship's body.

When the pupils complete both missing sailboats, they continue working in their workbooks: they will find four different approaches that use the red and green memories, being asked to decide which ones are correct and which ones are not.

Group discussion

(direct control and programming) *How do these tasks differ from the previous ones?* (we have pre-made memories, but Emil is sleeping, which means we are planning the whole solution in advance)

(G1, G2) *Have you noticed that both tasks are almost the same? How are they different, though?* (there are arrows in the memories of the second task) *Which of the tasks was easier to complete?* (the arrows in the memory may shorten the program, but the memories can be a little more difficult to understand)

(G3, G4) *Which of the tasks did you find more difficult? Why?* (there is only memory in **G4** but...) *Did you create your programs by parts and checked them by waking Emil up even if you did not have a complete program ready?*

(G5, G6) *Did you fill in both patterns in these tasks? Did you work according to the workbook instructions and built the program in parts? Is it easier than to create the whole plan at once and wake Emil up afterwards?*

(G7) *How did you find out what the red and green memories do? How many places on the panel do you need to create the whole ship?* (four places, or — as we see in the fourth assignment in the workbook — five) *Would it be possible with only three places?* (Not with these memories. However, if we could add an up arrow to the beginning of the red memory… discuss) *If we had no memories but only the commands to place all pieces (the front of the ship, the middle part, the back, the first and the second part of the sail), how many places on the panel would we need to occupy to complete the ship?*

Emil the Artist • H

Educational objectives

- To find out how to **fill in** places in an **incomplete memory**, i.e. to determine what will Emil's memory do.
- To complete both memories according to the picture examples shown in the workbook.
- To complete a memory either according to the shadow on the stage or according to the resulting picture on the stage.
- To define memories for Emil according to the picture example in the workbook and the accompanying text instructions.

Computing-specific content

Until now, the pupils used one or two memories in their programs on the panel, all of them being pre-defined in the assignments. Sometimes, we tried to start a discussion whether it would be useful to add a navigation arrow into the memory etc., completing or improving the memory. It is thus natural that the pupils will now explore **how Emil, in fact, "learns" the commands that he keeps in his memories**. The picture instructions next to task **H1** in the workbook will steer them in the right direction. The initial tasks are built in such a way that the steps of one memory suggest the composition of the second memory. In the next task, the pupils will be completing both "unfinished" memories according to the picture examples in the workbook. This will be extended by adding not only the placement of pieces, but also the arrow-based navigation. All of the steps — together with the subsequent use of the completed memories — represent another small step toward the **creation and use of own commands** (which the pupils will create for Emil in the fourth and fifth worlds, and later create their own blocks in the Scratch environment as a part of the curriculum in Years 5 to 9).

In the sixth task, the pupils will analyse a partially completed African textile pattern and determine the second memory that would help them create such pattern in such a way that helps them **make a program that will occupy a very small number of places on the panel.**

In several tasks of this group, the pupils also think about how two or three memories are designed to "cooperate" well, complement each other and help us create a more complicated pattern or picture (questions such as *Where will Emil stop after running a memory so that he can start well with the second one*…).

Teacher support and commentaries

H1

S: Follow the task in the workbook.
WB: Learn how to fill in a memory:
Fill in the red memory and program Emil to repeat the traffic signs.

Reading and studying the task, the pupils will realize that the green memory can help them create the first of the two alternating signs. Perhaps they will create a single-step program, containing only the sign of the green memory, and wake Emil up to find out. After they check that it really creates the whole first sign, they will clear the program and think about the red memory, which creates the second sign — but only partially. They will conclude that they should complete the memory in a suitable way. The picture instructions in the workbook will suggest how to do that: they need to click the unfinished memory and determine — i.e. program in the usual manner — the second command. There is only one possible solution (other solutions would only differ in Emil's navigation across the stage).

H2

S: Follow the task in the workbook.
WB: Fill in both memories so that they draw treetops according to these pictures.
Then complete the scenery. Draw your program here:

In the workbook, the pupils will find out the pictures which the green and red memories have to create. After completing the memories (and, in fact, **teaching Emil** what the top parts of coniferous and deciduous trees should look like), they will start planning a path that will let Emil complete all four trees to their liking.

However, let us discuss the following with the pupils: If they already completed the memories and made an incorrect program that they want to redo, it is not reasonable to use the Restart button (located between the left and right arrows on the screen) because they would also empty the complete memories. In this situation, it makes more sense to cancel individual commands from the end of the program by clicking the respective places on the panel.

H3

S: Finish the row of alternating flowers.

Each of the memories will probably complete one of the flowers. The content of the green memory (a blue flower) is already prepared. The pupils will make use of the first memory and, with the exception of colours, complete the first memory in the same manner in order to teach Emil how to complete an orange flower. Each of the memories will finish by navigating Emil right, which will make the whole program on the panel rather simple, occupying all of the places.

H4

S: Complete the memory then draw fish in the blanks.

The pupils already know the fish from task **A7**. This time, we will create them with Emil using his memories. First, they need to find out how Emil draws a blue fish, where he starts, where he finishes and what is the direction the fish will face. They can check their explanation by creating a short program where they use the green memory to create a single blue fish. They can then proceed similarly to complete the missing steps in the red memory, this time with the reverse navigation and a semicircle-shaped tail.

Text

H5

S: Follow the task in the workbook to complete the picture.
WB: Read the first memory. Then fill in the second one correctly and write it down here:
Then add four boats to the picture – tow red and two orange ones. Draw your program here:

The pupils first need to examine the effects of the green memory. Reading and checking on the stage, they will find out that it creates an orange ship, starting at its hull and finishing there as well. After that, they will realize that the second memory should probably create the second ship, this time with a red hull. A part of the memory is ready, though, and the first two commands will suggest another difference: Emil starts painting the second ship at its sail. If the red memory should make use of the same trick as the green one (i.e. Emil remains in the same row after creating the ship and he only needs to move left or right), this memory should also make Emil return to his starting point, this time by navigating upwards.

Then, the pupils need to draw two orange and two red ships on the stage. For example, they can do so this way:

If the pupils decide to mix the four ships, i.e. draw one orange and one red ship in both the top and the bottom part, it will be much more difficult for them — precisely because Emil starts and finishes drawing the ship in the same position, which makes it easier for us to think about how to move him to the next position from which he starts drawing the next ship.

Among other things, this task should be the first experience of a situation in which we program a certain unit consisting of several steps (such as our ship in this case) and is we know that we need to place several units like that next to each other, we can simplify our situation if the robot starts and finishes in the same position when creating the unit (ship).

H6

S: Finish the pattern as seen in the workbook.

The pupils examine the pattern in the workbook and think about which part of it is created by the green memory (which is already complete and consists of one position plus navigating Emil downward. This position repeats in every second column of the pattern, which means that the down arrow comes in really handy).

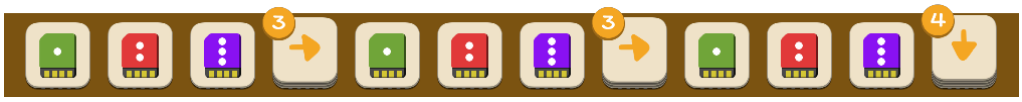
Based on the picture in the workbook, the pupils also need to think about the content of the red memory **that would help Emil complete the regular pattern.** Then, they teach him what to keep in the red memory and program the solution of the task in such a way that Emil copies the picture from the workbook.

H7

S: Follow the task in the workbook.
WB: Copy the green and red memories from here:
Fill in the violet memory to program the Martian's body and legs.
Use all memories to draw Martians according to the shadows, with Emil.

The pupils have exact instructions for the contents of the green and red memories, which means that they only need to copy that carefully into Emil's environment. They will examine the effects of each of them: the green memory will create the Martian's hands — however, it is important that Emil **starts** in the middle, between the hands, and **finishes** there as well. The red memory, on the other hand, draws the little Martian's head — again, letting Emil start and finish on the chest again.

In the workbook, we suggest that the pupils program the violet memory so that it creates the Martian's torso and legs. If we proceed carefully and plan the third memory in such a way that Emil returns to his starting point, he will be able to complete the Martian using only three commands on the panel: run the green memory, run the red memory, and run the violet memory. The complete solution might then look like this:



Group discussion

(complete and incomplete memories) *Have we seen empty places in memories in the previous tasks? What do they suggest?* (that Emil has not "learnt" the exact steps he needs to take when using a sign of a memory in the program) *Who managed to complete Emil's memory or memories?*

(H1) *What exactly does the green memory do? How did you decide what the red memory will do?* **(extension)** *Did anyone program a solution to this task that only uses eight places on the panel?* (this is possible if we use the teleportation feature and start with e.g. two up arrows)

(H2) *How did you know what exactly you need to add to the green and the red memories?* **(extension)** *Did anyone program a solution to this task that only uses eight places on the panel?* (again, this is only possible when using teleportation and start with e.g. three left arrows)

(H3) *What exactly does the green memory do? How did you complete your red memory? How do you add an arrow to the memory? Where will Emil finish after completing the panel on the program? And why will he be there?*

(H4) *What exactly does the green memory do? Read the steps in it one by one. Which arrow did you use in the red memory? Why?* (left arrow because the memory starts with the green body of the fish and its eye — and the tail is left of the body according to the shadow) *Does anyone have free places left on the panel?* (if we move Emil carefully and without any "intermediate steps" between the shadows of the fish, we can finish with two free places on the panel, but not more)

(H5) *What exactly does the green memory do? Where does Emil start and where does he finish? How did you teach him the red memory: where does he start and where does he finish? Is there any difference between how he draws the orange ship and the red ship?* (he draws the orange ship from the bottom up and returns to the bottom, but he draws the red one from the top to the bottom — and it is up to the pupils whether they have Emil return to the top or they let him move, say, to the left. However, if he returns to his starting point, it might be easier for the pupils to think about where to navigate Emil before he starts drawing another red ship *D*

(H6) *Did you manage to make an exact copy of the picture in the workbook? How many free places are there left on the panel?*

(H7) *How did you fill in the green memory? What about the red and the violet one? What kind of a program on the panel will draw a complete Martian?*

Emil the Artist • after H • Without computer

Educational objectives

- To strengthen the understanding and skills of **using and creating memories and programming** with the use of the memories.
- To analyse given memories — as **an extension to the language of navigating Emil** — and to use them to solve a given problem.
- To decide which version of a memory (from a given set of alternatives) and a given program can correctly complete a given picture on the stage.
- To decide how we need to complete a given **extension to the language** to program Emil using three memories that let us create a given picture using the three "new" commands (memories).

Computing-specific content

We strengthen the pupils' experience and understanding of the fact that the memories actually represent **"new" commands** consisting of basic commands, serving as an extension to the pre-existing set, i.e. the language of navigating Emil and programming his future behaviour. If the memories are thought out well, they might help us to **solve problems more easily**, not only in terms of the **number of steps** (places) of the program, but also in terms of **simplifying our thinking** about the solution.

Another important experience that is being systematically strengthened in the pupils — which occurs again in the final unit of tasks — is the fact that **the complete program for Emil does not only consist of the plan on the panel, but it includes the content of the memories as well.** If we change the commands in the memory in the same program, the overall behaviour of Emil will change dramatically.

Teacher support and commentaries

WB: Use these three memories and no other commands to program Emil's path from start to finish.
Write your solution here:

The three memories represent the only three commands that allow the pupils to plan Emil's path. The pupils learn to carefully examine each of the memories and express the whole solution to the task only using the three new commands.

WB: Emil is to complete the cars with the program on the panel, with the green memory.
Out of the A, B and C green memories, which one is correct?
Mark one you think is correct: *A.* *B.* *C.*

The pupils see a picture on the stage that is almost complete (i.e. the assignment of the original task) and the final program to create it, along with three possible definitions of the green memory. Which one is correct?

The pupils will first read the program to find out Emil's position when running the green memory for the first time. Thanks to that — and thanks to the shape of the car that the green memory should complete — they will be able to decide if the content is correct. Memory A can be excluded quickly as it places both parts of the chassis and both wheels into the same position. Memory C, on the other hand, can be excluded because Emil is currently standing on the left half of the car's chassis, but Memory C draws the car from right to left. Is B the correct answer then? The pupils should continue reading the program with the green memory marked B and check if it correctly completes the second and third car.

3 ***WB: Program the third memory for Emil to get out of the labyrinth using only memories and no other commands.***
Write the program for the third memory on the panel below:

This task is similar to the first one, but this time, the pupils need to design the third memory by themselves so that they have a useful trio of new commands that will help them program the whole path. Let us notice that the program may only consist of five places — fortunately, it will begin with a stack of two green memories and finish with a stack of two red memories. This means that we will only need three places!

4 ***WB: This is Emil's self-portrait. Read what each of the memories does. Then use them and program Emil's self-portrait.***
Write your solution here:

Again, the pupils have three pre-made memories at their disposal and need to use them to program the completion of the shadow parts in Emil's self-portrait. For that, though, they will need arrows to navigate Emil to the positions in which he should start running the respective memories. In this task, careful reading of the memories and their wise combination into the final program are the key steps.

Group discussion

(task 1) *How many places did you need for your program? How did you proceed with your solution of the task?*

(task 2) *Which version of the green memory is correct? Why not A? Why not C?*

(task 3) *How many places did you need for your program?*

(task 4) *How did you determine the position Emil needed to reach before he started using the memories? How many times did you use the green memory? What about the red one? What about the violet one? Where exactly did Emil stop after your program?*

Emil the Artist • X

Educational 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 third world.

Computing-specific content

In these extensions, all computational skills, concepts and constraints presented in the third world are summarised in a varied order and several groups. Now, they need to recognize them and make use of them when working on similar, but often more difficult, problems.

Teacher support and commentaries

X1 ***S: Check your solution of the task 6 on page 34. Can you create other interesting tiles?***

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

The pupils can check whether their ideas from task **after B6** were correct. The task then invites them to try other tiles as well — and there are certainly many interesting ways to use them, see right.

X2 ***S: Create various interesting patterns. Share your creation by e-mail.***

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

This task is similar to task **B6**, but the pupils can use more pieces and create a wider variety of patterns.

X3 ***S: With Emil duplicate the upper row to the shadows.***

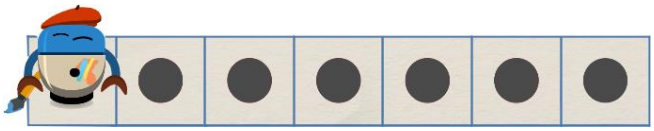
[Do not assign this task before the pupils complete the **E** tasks.]

This task is similar to tasks **E3** and **E5**, but the pupils can use more pieces and create a wider variety of patterns.

X4 ***S: Check your solution of the task 1 on page 43. Then use the same memory in your own programs.***

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

This task allows for the creation of interesting variants of the program whilst using the same memory. The pupils can come up with various tasks, programming resulting pictures such as this one:



X5 ***S: Check your solution of the task 2 on page 43. Then use these memories in your own programs.***

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

This task allows for the creation of interesting variants of the program and invites them to experiment with it whilst using the same memory. The pupils may create various extensions of the assignments for their classmates.

X6 ***S: Now use these tiles and memories to create interesting patterns. Then share your creation by e-mail.***

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

Free creation, similar to the tasks in unit **C**. The commands for Emil and the possibilities (memories) are larger now.

X7 ***S: Check your solution of the task 5 on page 44. Then try other interesting patterns.***

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

A task suitable to practice work with the memories — their definitions and use. The pupils may copy the program from the workbook and teach Emil various contents of the green memory one by one, studying the resulting image will be created by the program on the panel with a given definition of the memory.

X8 ***S: Create your own African textile pattern. Share your creation by e-mail.***

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

X9 ***S: Complete the pattern. Use all three memories.***

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

X10 ***S: Program memories, then the panel so that Emil completes the pattern.***

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