About this teacher material

Our new method for programming education at Years 3 and 4 of primary school consists of the Emil software environment (a software application), teacher materials and a workbook. A professional development session constitutes another critical part necessary for the successful implementation of this method in schools.

This is the first part of the teacher material for teachers[1] of Years 3 to 4 of primary schools (the second and the third parts of the teacher material will focus on Emil's second and third world). It is organized in **units of tasks[2]** in each world for Year 3 (similar to the software itself): each unit of tasks constitutes a separate short chapter spanning through one to two pages. Each of these chapters has the same structure:

Learning objectives – describing the specific learning objectives of the whole unit of tasks.

Computing-specific content – explaining in simple worlds which computing concepts and procedures these tasks support and develop and how they subsequently contribute to achieving the general and specific learning objectives of Computing in Year 3.

Teacher support and commentaries – this part sometimes starts with some common introductory notes. These notes are then followed by short commentaries on each task. We use the following notation in the heading of each task:

A1 | ***S: Text ...***

This label indicates that a commentary to the first task of the unit **A** follows, that this task has no complementary material in the workbook, and that the task itself is presented in software (that explains symbols **S:**) and the assignment is: ***Text ...***

1 | ***WB: Text ...***

This label indicates that the commentary belongs to to the first task of a unit of tasks **after A** or **after D** etc., that the assignment is presented in the workbook only – (that explains the ***WB:***) and the assignment is: ***Text ...***

B1 | ***S: Text ...***
WB: Text...

This label indicates that a commentary to the first task of the **B** unit in the software environment follows, that the task continues in the workbook, that the assignment in software is ***S: Text...*** (often only including the words ***Follow the task in the workbook.***) and that the assignment in the workbook is ***WB: Text...***

Group discussion – in this part, we provide teachers with suggestions regarding a discussion after completing a unit of tasks[3]. All of the suggestions in this part are provided in the form of **questions for the teacher to ask** with the group of pupils, to lead them to a discussion, i.e. to look for and think about the right words, arguments and explanations. We consider this part of the process to be key important as it represents an important form of peer learning, a form of group feedback and an opportunity for the teacher that can be used to strengthen and systematize the knowledge of the pupils, as well as a tool to provide formative assessment. Gradually, the pupils will get used to using their workbooks during the discussion so that they can read their records of steps, their own solutions or findings… We rely on the pedagogical mastery of the teachers, who should not correct any suggestions that may be partially or completely incorrect – instead, by asking more questions, they should motivate the pupils to explain and defend their thinking and procedures.

Extensions – with some units of tasks, we provide interesting suggestions regarding how to extend the tasks. However, we want to stress that there is already a wealth of materials in this workbook and software environment. However, if the teacher sees fit, he or she can provide some interesting suggestions to some pupils.

First world – Emil the Collector

We do not want to spend too much time introducing the first world as the readers know it from their PD session already. This part should only help with clarifying correct and consistent computational concepts and names for the individual components of the screen. Of course, we do not want to dwell on these words and do not assert that they are all 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.

Emil for Year 3 consists of three **worlds**, first of them being **Emil the Collector**. We sometimes call it *the first world* or *the green ball*. This world contains an ordered progression of **units of tasks** – a string of nine letters **A**, **B**, **C**… to **H**, and **X**. When we choose a letter – a particular unit of tasks – to continue with, a sceen with the first task of that unit opens. Here we can either exit this unit of tasks or move to the next task (if this one is not the last one), restart the task, or return to the previous task (if this one is

[1] we have developed our method in such a way that, apart from the introductory PD session (and a good portion of enthusiasm and goodwill) the teaching content itself would **not require any special education in Computing or Informatics or Computer Science**, except for basic computer literacy, making it **appropriate for every teacher in primary education**.

[2] grouped into units of tasks naed by letters **A**, **B** etc.; or **after A** etc.

[3] however, teacher may decide to have such discussion more often than at the end of the whole unit of tasks only

not the first one). In the top-left corner, we see the indicator of the world, a letter of this unit of tasks, a number of this task within the unit, and whether there is any complementary material in the workbook. In the bottom-right corner we see the button that turns on Emil's "turbo" mode (let us leave that for our pupils to explore). On the screen, we also see Emil and his **stage** with **positions** and various things on them (objects, letters, numbers etc.), and a **tray** or a **shelf**, which will store the objects collected by Emil. His stage contains rows and columns of positions, with some of them missing in certain tasks (representing a kind of 'holes' in the stage). The shelf, which appears above Emil's stage in certain tasks, has a set number of **places**, from the first one on the left side to the last one on the right side. The number of places of the shelf is not the same in all tasks.

In the first world, if the pupils take a wrong step/decision in their solution, they cannot *undo it*, they have to restart the task.

Map of the complete intervention

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

Workbook

The workbook is an inseparable part of our method. The software environment and the workbook are both basically useless without each other – the tasks are often structured in such a way that a part of the task is visible only on-screen (e.g. the actual stage of Emil) and the assignment itself can only be found in the workbook.

Even though the pupils always work in pairs and we encourage them to communicate and collaborate constantly, each one of them has his or her own workbook. We teach the pupils to use their workbooks to carefully write down everything we ask for in the assignments. The workbook will serve as their 'journal of computational thinking': a portfolio, which illustrates their learning process. In addition, it plays a key role in the lesson as well: the pupils develop their own strategy of writing their own solutions and procedures, which they later use as their record in the group discussion, being able to reproduce, analyse, compare, share, modify etc. That way, we fulfil one of the most important objectives of computing education: at the computing lessons, our own processes, records and programs turn into **objects that we can think about and discuss** – they are our "thoughts", expressing our solutions.

In the workbook (in the part dedicated to the first world), we can find two types of "chapters" (of one or two pages): they either accompany a unit of tasks in the software environment (chapters **B**, **C**, **D**, **E**, and **G**), or they belong to the "**after** a letter" unit of tasks (chapters **after A**, **after D**, **after G**, and **after H**). It goes without saying that the chapters of the former unit are necessary when working with the software environment. However, the chapters of the latter unit can be used at the discretion of the teacher. They can be skipped in their entirety, or they can be used as homework assignments or suggestions for classroom work without computers (either in groups or individually) — which we consider to be a major part of learning. Similarly, it is up to the teachers to decide how they will organize group discussions included in the material after each "**after**…" unit, if at all. That said, we consider these units of tasks to be an excellent tool to provide formative assessment of the pupils – a thorough analysis of the pupils' solutions (together with continuous observations and discussions with the pupils) gives us a unique opportunity to identify potential misconceptions and to make sure that we have reached our learning objectives with our pupils.

Common pedagogic principles

Again, we should not forget that this short document does not replace the teacher's attendance of the PD session, which we consider to be integral for everyone. In this section, we only provide a short summary of the basic educational principles:

- we are striving to utilize the full potential of unique benefits of primary education, i.e. the natural interconnections between mathematics, language, local history, computing, ethics etc. We would like the teachers to seize all opportunities to the fruitful use of these connections. We aim for the holistic development of pupils,
- the pupils always work in pair[4],
- the teacher never explains; he or she "only" organizes the lesson, supports the work of the pupils, asks relevant questions – simply put, the teacher facilitates the learning process of the pupils,
- the pupils mostly work in the 'computer – classmate – workbook' triangle, having a multitude of opportunities to shift their focus to different representations of the problem,
- the Emil software environment **does not provide any feedback**; the pupils in the pairs provide that to each other, getting more feedback in group discussions afterwards. For them, they need workbooks as a necessary instrument and a record of their solutions, discoveries and explorations,
- programming is a complex form of problem solving in which we want the pupils to read (texts and other representations or records of work), think, discuss, compare, correct, explain, plan and execute, identify constraints and persevere in

[4] unless the teacher has a very good reason to take a different approach in the given situation

seeking the solution, collaborate and communicate, focus, express themselves, enjoy their discoveries, enjoy teamwork, and enjoy the learning itself.

How to organize our lessons

In **A**, **B** and other units of tasks named by single letter, the pupils work in pairs, using only one computer (a tablet or a different kind), constantly discussing their intentions and approaches, but writing down their own records separately – either making the same record, or incorporating their own differences. After having solved the whole unit of tasks (or with a higher frequency), the teacher organizes group discussions that are of key importance within the learning process of each pupil. It has proven to be beneficial to organize (if possible) these discussions sitting on a carpet in front of the classroom, beside the teacher's computer, viewing the projection of his or her screen. In these group discussions, we take advantage of various activation methods to retain focus and engage the whole group in parallel. The discussion is managed by the teacher, but it is the pupils who are to show initiative. The teacher does not provide the correct answers, either. He or she can take advantage of previously noticed mistakes or problems in the solutions. That said, these discussions cannot last longer than for a couple of minutes.

When solving tasks of the "**after...**" type, we leave it at the teacher's discretion to decide, based on past experience, how to organize a group discussion, if at all.

Performance and content standards according to the national curriculum for computing

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

Limited implementations of the first world

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

In particular, should the teacher opt for an abridged implementation, the pupils may miss an opportunity to gain more experience with navigating Emil when building numeric expressions on the shelf, with searching a path whilst having a limited number of clicks available, but most importantly, with planning, i.e. programming Emil's future path in the **H** unit of tasks, and with reading and interpreting a pre-made programs (in the **after H** unit). Let us notice that in the abridged implementation, the pupils only complete one **after…** unit of tasks; however, they work with the workbook in units **B**, **C**, **E**, and **G**.

If the teacher adopts the minimal implementation, the pupils will learn how to control Emil in his stage, how to make him collect (some or all) objects into the tray or on the shelf; however, they would not find out about an important constraint, i.e. the fact that it is not possible to return to a position that had been previously marked (it is only possible to fly over it). They would also skip the tasks with a pre-set order of certain objects on the shelf (working with repeating patterns, with a limited number of available clicks and with an on-screen record of the click order – a mechanism that will change to a way of planning (programming) Emil's future path in the final unit of tasks. They would not learn to read these plans and think about them, not to mention their creation itself. Let us notice that in the minimal implementation, the pupils only complete one **after…** unit of tasks; however, they work with the workbook at letters **B** and **C**.

On the other hand, we have to stress that

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

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

- abridged implementation:

- minimal implementation:

Emil the Collector • *A*

Learning objectives

- To collaborate in pairs when solving the tasks, and to discuss the procedures and solutions.
- To explore how to navigate Emil, the possible movements, his indication of problems, and the way his actions are performed.
- To understand the overall direction in the Emil environment (the choice of the world, the choice of the unit of tasks — letter, a task, moving to the next task, completing the unit of tasks, restarting the given task, terminating the application etc.).
- To collect **objects** — or a certain **selection of objects according to a given requirement** — **into the tray** or **on the shelf** and to consider alternative procedures.
- To think about the **order** of objects when collecting them.

Computing-specific content

The pupils learn a new way of **navigating a character**, indicating the **target position** on the **stage** by clicking or touching it — however, this is only possible for the rows and columns in which Emil is located. Another **constraint** (introduced as early as in the **A3** task) is that there are missing positions: Emil cannot fly over a "hole" (no position) in the stage.

The most important feature in this unit of tasks is the **order of objects** in which the pupils collect them with Emil. The objects represent **data** (such as numbers, letters, coins etc.), the **tray** and **shelf** represent a certain **data structure** (or set): in the former, data are not **ordered** in any way (meaning that we cannot say that a certain item in the tray holds the first, second or other position…). We might remember that we have placed an object into the tray as the first or second one. However, after solving the task, the information is not preserved in the tray at all. On the shelf, the situation is different: even after having solved the task, we see which thing arrived as the first one, which one was the second etc.

The pupils also think about the fact that the objects, i.e. **data**, have certain **properties**: even when not in the tray or on the shelf, they can be sorted into sorts such as vegetables and "non-vegetables", odd and even numbers etc. Some data – such as numbers 1, 2 etc. – also have their own **natural order**, which may be **ascending** or **descending**.

Teacher support and commentaries

In the **A** unit of tasks, the pupils work only with the software, i.e. without the workbook. As it is the first unit of tasks for the pupils to solve with Emil, and given the fact that everything in the software environment and the pedagogical approach is new to them, we suggest that teachers consider and choose one of two available procedures to how the work of the pupils is organized in this unit of tasks. In any case, the pupils will **work in pairs** – they will talk, explore and solve problems together. However, we can perform the group discussion of the whole class or group in two ways:

- either after every single task — to make sure that all pairs have discovered and understood what there is to solve and how to do so,
- or at the end of the whole **A** unit of tasks (or in smaller subgroups, recommending grouping tasks **A1, A2** and **A3**, then **A4** and **A5**, and, finally, **A6**).

That said, all discussion suggestions for the tasks of this unit are provided after the Teacher support and commentaries. In the later units, **B**, **C** and so on, we recommend to organize a class-wide discussion only after having solved all of their tasks; however, the decision is up to the teacher as well.

A note on navigating Emil: in this unit of tasks, pupils will gradually discover how to navigate Emil. Initially, many of them will only click (or tap) the positions in the row or column located next to Emil to instruct him to fly there. Only some of them will find out within the first tasks that they only need to click the destination position in the row or column even if it is further from Emil by several positions – in one move, Emil will fly here. However, the teacher should not discuss, explain or compare these two ways of direction. Gradually, all pupils will find out that they do not have to click the adjacent position and move Emil position by position — they will find out no later than in the **E** unit of tasks.

A1 ***S:* *Help Emil put all the things into the tray.***

In this task, the pupils try and explore how to navigate Emil. Among other things, they will find out that they are unable to drag Emil and that he cannot move in diagonals. Some of them will then start moving him by clicking or touching the nearest adjacent positions, others will discover that it is enough to click or tap a distant position in the same row or column that Emil is currently located. Both procedures are correct, which is why **we do not compare or comment upon them in front of the pupils.**

The pupils will also gradually discover that Emil will gradually "take and drop" everything he flies through **into the tray**.

Furthermore, it will be their first time to experience the fact that the Emil environment **does not provide any feedback** to them — the pairs have to agree whether they have successfully completed the task.

A2 ***S:* *Now help Emil collect only the fruits.***

This is a simple variant of the previous task, with the addition of the fact that now, Emil has to collect only those things into the tray that fulfil a given condition (criterion). In a discussion about the things they have collected, the pupils may find out that **it is possible to move things in the tray using their mouse or finger**, which allows them to organise the things somehow — they may put all of the collected pears together or place an object that was not supposed to be collected into the corner etc.

A3 ***S:** Help Emil collect only the fruits, this will go on the shelf.*

This time, we have collected objects **on the shelf**, preserving the order in which Emil collects them. There is a new constraint that the pupils encounter in this task — some of the positions are missing in the stage and, despite his unsuccessful attempts, Emil cannot fly over such a gap. The pupils may navigate Emil in different ways, but most certainly, the first thing on the shelf will be an orange or a pear (if Emil does not collect a carrot as well). Emil should place exactly five objects on the shelf.

A4 ***S:** Help Emil collect all the even numbers.*

Emil should collect only numbers **2, 8, and 4** — and none of the others. The pupils may take different procedures; however, they must always start with **2**.

A5 ***S:** Now collect all the odd numbers.*

Emil should collect only numbers **1, 3, 5, 7, and 1** — the number **1** is present twice on the stage. The pupils may take different procedures, but they must certainly take **1** or **3** as their first number into the tray. However, after the numbers are placed into the tray, **other pupils have no way of knowing** which number was taken by Emil as the first one, which was the second etc. In the group discussion, however, it is certainly worth asking *whether they could navigate Emil in this task in such a way that they would collect the number **1** as the last one (which number 1, though?), the number **3** as the last one, the number **5** as the fourth one* etc. We teach the pupils to realize that there is a difference in the order of Emil's steps (his direction in the stage) and no order in the tray or the order on the shelf.

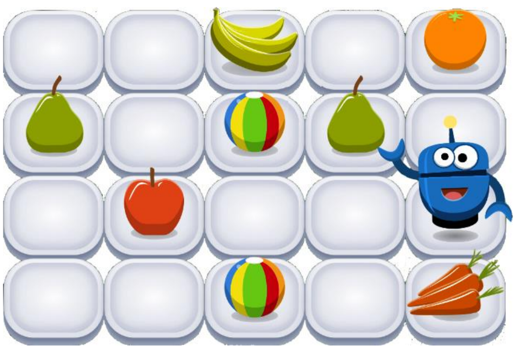
A6 ***S:** Collect the numbers from the smallest to the biggest.*

The pupils need to collect numbers in the order **1, 2,**... on the shelf. At the same time, they learn not to see the objects on the stage as mere targets that are to be collected, but also as temporary "obstacles" on their path to another number. Some may be surprised that the number **8** is missing, but in pairs, they will arrive at the conclusion that this does not affect the assignment, i.e. to collect the numbers in ascending order on the shelf.

Group discussion

As suggested above, the teachers have to decide if they discuss the individual tasks with the class right after their completion, after the completion of several tasks, or after the completion of the whole unit. Either way, here are some interesting discussion points to look at after completing the tasks from the **A** unit:

(navigating Emil *How do we navigate Emil? How to instruct him to move to a certain place? Which directions can he move in? Which ones are not possible to use? Who has tried to move diagonally? Can he fly away from the stage? How does he actually move? Does he fly? Or does he walk?...*



(the objects obstruct each other) *What happens when Emil flies over an object? Which objects did Emil collect in these tasks? What is fruit? What are vegetables? Which of the objects in the first three tasks were neither fruit nor vegetables?*

What numbers was Emil supposed to collect in the second trio of tasks? What are odd and even numbers? What was Emil supposed to collect in the first task? What about the second task? What were the differences? (sometimes we collect everything, sometimes only something, a certain kind of objects...)

(the picture on the right side shows the **A2** stage) *Look at this stage and say if Emil can collect the orange as the first thing. What about the apple? Or a pear?* (depends on the choice of pear) *What are the items he can collect as the first ones? Can the bananas be collected as the third item? Can they be taken as the fourth item?*

(objects are collected into the tray or on the shelf) *Where do the objects that Emil collects fly? What is the difference between the tasks with the tray and those with the shelf?* (order — even after having solved the task, we see which thing was taken as the first one, the second one etc. In the tray, we see everything that Emil has collected, but we can't tell which was the first, the second, the third item etc.)

Now, let us show the following picture to the pupils. *How do we call the thing on the left side and the thing on the right side? On the left, we see what Emil has collected when collecting on the shelf. What was the first thing taken? What was the second one? What was the last thing? How do we know? On the right, we see the things Emil was supposed to collect into the tray. What was the first thing taken? What was the second one? What was the last thing? Do we know at all? Why not?*

Let us take a look at task **A4**. *Did anyone collect the number 4 as the first thing into the tray? (if not, why?) Which number can he or she take as the second one? Which one can be the third? How do we know that we have completed the task successfully?* (if there's no even number left on the stage)

Let us take a look at task **A6**. *How many places are there on the shelf? Will all numbers fit on the shelf? Which number has to be the first one? Which is the second one? Which is the last but one?*

Making connections to pupils' previous experience

In the lower years, the pupils may have already played with some programmable toys such as Bee Bots or similar. If this is the case, we should discuss that previous experience with our pupils and support its transfer to this new context of Emil.

How did we control those? What did we click on? What did we push? Where does the bee live? What about Emil? (the bee "lives" on Earth, while Emil lives on the screen of a computer or tablet…) *What were we able to do with the bees? How did we make a bee go forward? What else was it able to do? Can we do that with Emil, too? What kind of problems did we solve back then? What kind of problems do we solve now? Does the bee's mat resemble Emil's stage?*

Emil the Collector • after A • Without computer

Learning objectives

- To strengthen the knowledge and skills acquired by the pupils in completing the **A** unit of tasks.
- To complete workbook tasks (probably individually, perhaps with a subsequent discussion; We may make use of the visualizer during it).
- Based on the resulting state on the shelf, to look for such a procedure taken from Emil's starting position that allows for achieving the given result.
- To consider various procedures. To give reasons why there is **no solution** for certain assignments.
- For a given initial on-stage situation, to look for such **paths** for Emil that will allow him to collect only those shapes that **meet a given criterion** *(all circles, all orange shapes, all orange and blue shapes etc* — shapes and nothing else).

Computing-specific content

The pupils also develop their **perception of the final order of objects**— coins or fruit — expressed by their **place** on the shelf.

In the second task, we see the **initial stage** and the **final outcome on the shelf** that we are to achieve. Our task is to look for such a path for Emil that will allow him to collect the objects in the exactly same order on the shelf. The pupils should realize that:

- Emil cannot jump over the missing (NB: not empty, missing) position (a certain "hole" in the stage), thus being unable to fly directly from the pears on the left side to those on the right side and vice versa,
- Emil may fly over the position from which he had collected a pear or an apple because it is now empty.

In the third task, the pupils are to understand the chosen **criterion (condition) for the choice** of objects that Emil should collect. Some of the criteria are **simple** (*all circles and nothing else*), some are **compound** (*all squares and all orange shapes* and nothing else). We want the pupils to think about which shapes **fulfil** this exact criterion — either a simple one or a compound –— and which can, at the same time, be collected, not being obstructed by the shapes we should not be collecting.

Teacher support and commentaries

> Individual work with the workbook at the computing lessons may be new and surprising for the pupils. That is why we recommend that the pupils first complete some tasks from this unit (**after A**, p. 3) at school (possibly together as a group): task **1**, followed by, say, the first two assignments in task **2**, and the first two assignments in task **3**. This way, we can immediately discuss and clarify all the necessary points together (*see the discussion points below*) and leave the

remaining assignments in tasks **2** and **3** up to the individual work of the pupils (and perhaps address those in the initial discussion at the next lesson).

We need to make sure that in task **2**, the pupils have noticed and understood the sentence **Start over after each task** (i.e. that Emil has to start again with the stage full of apples and pears). In the discussion, we also need to clarify the fact that if Emil flies over a position with a piece of fruit present on it, he will collect it and place it on the shelf — leaving it **empty** and free to **fly over it again**. We also need to mention that the middle position in the top row of the stage is missing, meaning that he cannot fly through that way.

Let us make sure that the pupils **write down** their procedures **in the workbook**. The way in which they mark Emil's path is for them to make or choose according to their liking. It is important, though, that they be able to reproduce and describe their procedure, i.e. to "read" it for the others.

1

WB: Emil has collected the coins on the shelf. You can see them here:
Which coin was last? What was second? What coin was collected second to last? Which coins do you know of that are missing from Emil's shelf?

This task is a simple check of whether the pupils correctly understand the **order of objects** (in this case, coins) collected on the shelf. It also checks the knowledge of our coins — the pupil should notice that the 2p and 20p coins are missing on the shelf.

2

WB: This is Emil's stage of fruit:
Which of the shelves can you and Emil fill like this? For each task draw the path Emil will need to take.

This is basically a set of six tasks with the same initial situation on the stage (in the top-right corner of the page in the workbook). Each task specifies the **resulting shelf after Emil collects the objects**. We expect that the pupils will draw on the stage with the shadows of apples and pears, indicating the path that Emil must take in order to achieve a given situation on the shelf.

Two of the six tasks have no solution. However, the left assignment in the second row also tempts the pupils to say that there is no solution for it, despite the fact that there actually is one. We recommend that the teachers systematically develop the following approach with their pupils: *If we have decided to say with certainty that there is no solution for a given task, we need to be able to explain why we think so* — providing a rationale behind our decision.

The pupils may explore and check their solution in task **X1** in the software, where we suggest that they create a similar task for their classmates (maybe even one that has no solution).

3

WB: This are Emil's stages of shapes. Draw out Emil's path to collect the shapes.
Can Emil collect all the circles, and no other shapes?
Can Emil collect only the orange coloured shapes, and no other shapes? ...

This, too, is a set of six tasks that provide some food for thought and stimulate a subsequent discussion. Each task represents a criterion (a condition) that should make us decide which shapes should be collected by Emil and which should not. The first three tasks specify a **simple criterion** (*all circles and nothing else, all orange shapes and nothing else, all triangles and nothing else*). The remaining three tasks contain a **criterion consisting of two conditions** (*all orange and blue shapes but nothing else, all squares and triangles but nothing else, all squares and orange pieces but nothing else*). Some of the conditions are related to the shape of the piece, others are related to its colour. The addition of "*but nothing else*" is important in each task — otherwise, we could have Emil collect all of the available shapes into the tray and each task would be completed correctly. Three of these tasks have no solutions — it is impossible to plan such a path for Emil that would collect all of the required shapes but not any others.

The pupils may explore and check their solution in task **X2** in the software, where we suggest that they create a similar task for their classmates (maybe even one that has no solution).

Group discussion

Even in the case of the "after" tasks, there may be a situation when we wish to discuss the tasks with our pupils, asking about how they managed to complete them or to point their attention to certain interesting events in the tasks. The task assignment may be displayed for everyone using a projector or, in the case of tasks **2** and **3**, by showing tasks **X1** and **X2** in the software.

(task 2) *In the beginning, the stage with fruit always looks the same. Can Emil move from his position upward? If not, why? If he moved by one position to the left and came right back, how would the stage change? What would the shelf look like? What if Emil moved one position further to the left? What would happen then?*

Let us now read the first task, look at the resulting shelf and Emil's stage: What was the first thing that Emil collected (which one is the first on the shelf)? An apple. Good. Which apple on the stage could that be? Let us take it. What did he take next? Which apple could that be? …

Let's take a look at the left assignment in the second row. Which apple may Emil collect first? What should he take next? And then? What are the options?

Which of the tasks cannot be solved? Why? Let us try out the solution in task ***X1.***

(task 3) *What was Emil supposed to collect in the first task? How many objects from his stage should he collect? Who can read their solution of this task from their workbook? Which circle could he collect first? What exactly did Emil have to collect in the second task? How many such shapes are there on the stage? Can he get to each one of them? Which one can or must he start with? In which tasks is it impossible for Emil to collect everything he is supposed to? Why?*

What exactly was he supposed to collect in the sixth task? How many shapes in total are there on the stage? (10 shapes) *How many pieces from the total are squares?* (three) *How many pieces from the total are orange?* (three) *How many pieces in total does he have to collect?* (five) *Why not six?*

Let us try out the solution in task ***X2.***

Emil the Collector • B

Learning objectives

- To learn to **work in pairs**, going **from the workbook to the computer and back to the workbook**, continuously writing down solutions, findings and answers.
- When navigating Emil, to perceive the on-stage objects as **obstacles** as well (because some of them prevent us from collecting other objects at a certain point).
- To see the shelf or the tray as a **whole** (the shelf may represent a two-digit number or a word consisting of letters; the tray with coins may represent a certain sum of money — a sum of all of the values of the coins it contains).
- To consider **alternative solutions**: the cases when they are **different** and when they are the **same** (say, collecting the same sum by picking up coins of different values).

Computing-specific content

The pupils strengthen their **perception of the order of the collected things-digits** (e.g. when putting together a two-digit number). They also deepen their experience with the fact that a certain object **cannot be collected** at a given point because other objects prevent us from doing so. However, with Emil moving around the stage, the situation changes.

Now, the shelf will not be seen as a collection of ordered digits, but also as the **representation of a single value** such as a two- or three-digit number or a word — names of seasons etc. Similarly, we can see the tray as a **single value** as well (e.g. the sum of coins that are placed in it).

The pupils also think and provide evidence of whether two solutions of a problem are **different** or whether they are **the same**. Among other things, they talk and think about the fact that the resulting sum of £1 and 50p can be achieved by putting together **various combinations of coins** (such as 50p + 50p + 20p + 20p + 10p or £1 + 20p + 20p + 10p) or using the same coins but collecting them using different procedures or from different positions on the stage. When solving problems, pupils thus consider various features of **several solutions to the problems**.

Teacher support and commentaries

The pupils have already worked with the workbook, but only when completing the **after A** unit of tasks, i.e. without a computer. This is the first lesson where they read the instructions in the workbook and subsequently complete the task in pairs on the computer, only to return to the workbook to note the solution and answer various questions. We should not forget to repeatedly mention that they should keep writing down their findings, to answer all of the question, to write down each word or number they have found etc. — because only this will allow them to join the group discussion and to present their solutions, procedures and findings.

Before the pupils start completing the tasks of this unit in pairs, we display task **B1** by projecting it on the wall. Then, we read the instructions in the workbook and talk about two-digit numbers, saying what they are and how we will "write them down" by collecting them on the shelf. In front of the whole class, we navigate Emil to collect, say, the number **35**. Then, we point out the presence of the "**Start over**" control and actually use it. Afterwards, we ask the whole group: *What do you think: which is the smallest two-digit number we can put together with Emil? And which is the largest?* We do not comment upon their replies and suggest that they start working on the tasks in pairs using their computers.

B1

S: Follow the task in the workbook.

WB: Make as many two-digit numbers with Emil as you can. Start again each time.
I made these numbers: ...

The pupils will now see the shelf as a way to **write down a two-digit number**. First, they will look for — and write down — any two-digit numbers that they can collect (**starting over** after every number they find, i.e. with the same initial stage and empty shelf). In the supplementary questions, they will also think about the properties of the numbers: which one is the largest or the smallest number that can be written down etc. We want the pupils to realize that although there are digits to write down the number **20** available on the stage, we cannot collect them with Emil that way.

Similarly, the number **98** may seem to be the largest possible number to write down but again, we cannot write it down with Emil.

B2

S: Follow the task in the workbook.

WB: Create at least three different three-digit numbers that start with a 4.

The task is similar to **B1**; however, we put together three-digit number with a different initial stage. The smallest number that starts with the digit **4** will be **415**, the largest will be **487**. Pupils may write down the same numbers both in a) and b) in two cases: **419** and **469**.

B3

S: Follow the task in the workbook.

WB: Put together the names of the four directions on a map. Start again each time.

I made these directions:

This is the first time that the pupils will compose **words** on the shelf: the names of the cardinal directions on the map. They will succeed in writing down SOUTH, NORTH, and **WEST**, but they will not be able to write down **EAST** — the letter **E** is blocked by the letter **W**.

In addition to seasons, the pupils will be able to write down other words such as **HOT** or **WATER**, which the teacher can use for starting an interesting discussion. We will encounter word-building on the shelf again in other, more demanding tasks:

Again, we need to make sure that the pupils start over after having written down a word (i.e. with the same stage and empty shelf).

B4

S: Follow the task in the workbook.

WB: You have to pay £1.50 into the tray. Look for different solutions. Start again each time.

These are my solutions:

In this task, the pupils should look at the tray as a sum of money which they collect together with Emil. In that case, they need to “collect” or “pay” a sum of £1.50. They should look for a number of **different solutions** that should spark an interesting discussion in the class — if we collect the required amount as the sum of 10p + 20p + 20p and £1 into the tray, the first coin we take with Emil may be located in two places: either directly above Emil, or to the left of the £1 coin. In both cases, the coins in the tray have the same values, but we have (partly) collected them in different places. We let the pupils provide arguments. They may realize that the answer to the question, whether those solutions are different or not, is not easy and it depends on whether we are only interested in the resulting tray contents or we also take into account the path Emil took while collecting the coins. It is true that after having solved the task, **there is nowhere to see** Emil’s path. However, it is precisely this aspect that interests us from the point of view of computing — and soon, we will be actually **recording** Emil’s path. From **recording Emil’s steps**, we will later move on to **planning his future steps — programming.**

One of the pairs may come up with a solution when Emil collects the required sum, but there will be a button in the tray as well. We should discuss this solution and listen to arguments for and against the correctness of this solution. We need to accept the fact that the instructions do not forbid collecting the button.

Group discussion

(the shelf as a number, B1*What is a two-digit number? How many different ones did you put together? Which was the smallest one? Which was the largest one? If we start with a three, how many ways to continue are there?* (four) *Now, let’s start with an eight… How many ways to continue are there?* (again, four) *Can we assemble the number **98**? If not, why? If we start with a four…* (but that’s not possible)

(**B2**) *What is a three-digit number? Which were the largest and the smallest numbers that you managed to assemble in **a)** and then in **b)**? Did you also find a number that belongs to both **a)** and **b)**? Which one? How can we complete the subtask **a)** and what numbers can we create, if we start with the numbers **4** and **6**? Looking at the stage, using only our eyes to look for the smallest and the largest one of all available numbers that we can assemble with Emil, which one will that be?* (**145** and **786**)

(**the shelf as a word**, **B3**) *How can you assemble a word on the shelf? Which seasons did we write down? Which ones were impossible?*

(the tray as a sum, B4) *Which coin did you collect as the first one? In which direction did you first move with Emil?* (left, up, right) *Is it possible to complete the task if we start in any of these directions:* (yes)*What solutions did you find?* (write them down on the board) *Did anyone use the 5p coin as well? Did anyone collect the button as well? Is that a correct solution?*

Emil the Collector • *C*

Learning objectives

- To see the tray as a whole (as the sum of money it contains), but at the same time, to consider **the number of things** that we had previously placed in it.
- To clarify incomplete instructions (what are the *"good words"*, missing accents – if appropriate) and to follow the rules that the group has agreed upon.
- To assemble numeric equations on the shelf. To evaluate a given attribute against the content of the whole "shelf" (i.e. if the equation collected on the shelf is true or not).

Computing-specific content

The pupils now have to work with another **constraint**: in addition to keeping account of the total sum in the tray, they also need to be aware of the number of things (coins) that they placed into the tray. When looking for a path for Emil, they often need to factor in the missing positions on the stage and many of the things that represent obstacles.

The pupils discuss and think about another feature of the items collected on the shelf — the **length of the word** (written on the shelf).

When working on the third task, the pupils look for a way to assemble a required phrase on the shelf according to the instructions — an equality consisting of **numbers, operations** and the **equality sign**. Then, they should consider another property of the content — the fact whether an equality is true or false.

Teacher support and commentaries

C1

S: Follow the task in the workbook.
WB: Collect four coins to make 40p.
These are my solutions: ...

The required sum of 40p made up of four coins may only be collected as 5p + 20p + 10p + 5p. Emil may use one of the two 20p coins (and again, this opens up space for a final discussion about whether this constitutes one or two possible solutions).

A small reminder: the coins — or any other things — can be **dragged and dropped within the tray using the mouse or touch controls**, which may help the pupils when calculating the total sum in the tray: they can group the coins to form parts, say, placing the 5p and 5p coins right next to each other, then add 10p etc.

C2

S: Follow the task in the workbook.
WB: Use Emil to create as many good words as you can. Start again after each word.
These are my words: ...

The pupils are tasked to help Emil collect (and write down) various **good words**. First, they might want to clarify the notion of good words — we let them (only managing the discussion) **agree** upon their own definition of good words (perhaps including polite, meaningful, Slovak, English or other words…).

C3

S: Follow the task in the workbook.
WB: This is Emil's stage:
Try and find out which sums you and Emil can build. Check that the sum is correct. Write down your answers:

The task contains nine equalities: some of them can be built on the shelf whilst others cannot. For each equality, the pupils take a note of whether that equality can be built at all and whether it is true or false. Sometimes, they are surprised to work with false equalities such as **5 + 3 = 9**. Sometimes, they may be surprised by the difference in the form that the equalities take, e.g. **5 = 3 + 2** or **8 – 2 = 6 + 1**.

We should make sure that after having completed the task, all pupils automatically **start over**, with the same stage and empty shelf. The teacher may decide to limit the time spent working on this task by suggesting that the pairs only complete four out of the nine sub-tasks.

Group discussion

(the sum and the number of coins in the tray, C1) *How many different solutions did you discover? Are they different or not? Did anyone find a solution in which Emil used both 10p coins or didn't use any 5p coins? What is the largest sum that we can pay using four coins?*

(words on the shelf C2) *Which of the different words did you collect? What was the longest word that you managed to write? Which were the shortest words that you wrote?* (the pupils usually say three-letter words) *Did anyone find shorter words? And some even shorter ones?* (one-letter words such as **A** or **I**)

(equalities, C3) *Which of the given equalities are false? How did you check whether the equalities are true or false? Can you write down the following equality:* ***12 – 5 = 7****? If not, why?*

Extensions

(**C1**) To provide variety, we may suggest that the pupils try to pay a different sum, say, £1.50 using four coins, £1.50 using five coins, or to make up their own tasks in kind for each other (80p using six coins, £2.20 using five coins etc.).

Emil the Collector • D

Learning objectives

- To build the correct **numeric expressions** according to known mathematical rules using the objects available on the stage (i.e. numbers and arithmetic operators).
- To continuously think about the resulting value of the constructed numeric expression and its "elements": are they available for Emil or are they (temporarily or permanently) blocked by other elements?
- **[Extension]** To create alternative tasks for classmates in the pair or for other pairs (such as: *Use at least one two-digit number in the expression; Use only two-digit numbers;* etc.).

Computing-specific content

Whilst in the previous task, **C3**, the pupils constructed numeric equalities on the shelf according to the instructions — basically, they had to "copy" them correctly to the shelf — now they have to create expressions consisting of numbers and arithmetic operations with a pre-defined resulting value. That makes them think simultaneously (a) about the correct notation (structure) of such expressions; (b) about the available *construction elements* on the stage and their **availability** itself at every moment; (c) about the resulting value of the constructed expression. For example, in the expression **1 + 3 x 2** (or in any correct variation of it), which is a good candidate for completing task **D1**, the pupil can never reach the number **3** since it is obstructed by three other elements.

Teacher support and commentaries

These tasks have a relatively wide variety of solutions. In terms of reaching the learning objectives in computing, it is enough for the pupils to find one or two solutions for each task. However, if it suits your situation and you have pupils in class that are interested in these tasks, you can use these tasks to offer extensions various additional activities (see the final part on the **D** unit of tasks below). It is thus up to the teacher to decide on how much time will be spent working on this unit of tasks. The teacher may decide to move on as soon as the group completes tasks **D1** and **D2**, perhaps returning to the other tasks later or assigning them only to some of the pupils.

We see that all four tasks work with the same initial stage and starting point for Emil.

WB: This is Emil's stage:

D1

S, WB: Create a sum that makes 7.

Look for different solutions. I made these:

The pupils will probably start with very simple expressions such as **5 + 2** or **1 + 6** or slightly more complex ones such as **6 + 3 – 1**. Some may be interested in complex expressions such as **2 x 5 – 3**, **25 – 3 x 6** etc. Either way, they have to keep track of three things together: the availability of things (numbers and operations) on the stage, the rules of notation for numeric expressions, and the resulting value of the expression on the shelf.

D2

S, WB: Create a sum that makes 4.

Look for different solutions. I made these:

The pupils will probably start with very simple expressions such as **5 – 1** or **6 – 2** or slightly more complex ones such as **6 + 1 – 3**. However, some may be interested in more complicated expressions such as **52 – 46 – 3 + 1**.

D3

S, WB: Create a sum that makes 19.

Look for different solutions. I made these:

Again, the pupils will probably start with simpler solutions such as **16 + 3** or **25 – 6** or slightly more complex ones such as **6 x 3 + 1** or **5 + 6 + 2 x 4**.

D4

S, WB: Create a sum that makes 22.

Look for different solutions. I made these:

In this example, we may notice an important change: the shelf has only **four places**. The expression may thus contain only one operation (+, – or x) and two numbers, of which one will probably be a two-digit number. There will not be many solutions to this task then: **25 – 3** or **26 – 4**. Will anyone come up with another solution?

Group discussion

(**D1**) *Who has found solutions **5 + 2**, **2 + 5**, **6 + 1**, **1 + 6**? Has anyone got a solution with a subtraction sign — minus (e.g. **6 + 2 – 1**, **12 – 5**, **5 + 6 – 4**)? Can we use the multiplication sign as well (e.g. **5 x 2 – 3**, **5 x 1 + 2**, **6 x 2 – 5**)?*

(**D2**) *Did you find it more difficult to create expressions that result in **4** than when the result was **7**? Why?* (impossible to use only one addition; it is necessary to use subtraction — the minus sign — as well) *What is the simplest expression that has the result of 4 (e.g. **6 – 2**, **5 – 1**)? What kind of more complex expression did you create (e.g. **12 – 5 – 3**, **6 x 2 – 5 – 3**, **6 + 2 – 4**, **5 x 2 – 6**)?*

(**D3**) *What solution have you found? (e.g. **6 x 3 + 1**, **16 + 3**, **24 – 5**, **25 – 6**, **5 x 6 – 13 + 2**)*

(**D4**) *What solution have you found? (only the following two exist: **26 – 4**, **25 – 3**)*

Extensions

(**D1**, **D2**, **and D3**) The pupils may look for solutions to these tasks with various additional constraints such as *You have to use at least one two-digit number in your expression… You may only use two-digit numbers… You have to use at least two signs…* etc. They can either look for such solutions, or they can create tasks for other classmates.
An example expression for task **D1** that also uses two-digit numbers is **63 – 52 – 4**.

Emil the Collector • after D • Without computer

Learning objectives

- To strengthen knowledge and skills acquired when solving previous units of tasks when working without the computer (individually or in groups), especially when **looking for a path for Emil with a given target in an environment with various constraints and obstacles**.
- To understand and accept various additional rules when solving tasks (*follow the traffic signs,…*).
- To solve known computing tasks in other context (e.g. in an environment with traffic signs, alphabet etc.).
- To analyse the overall on-stage situation and add missing directions (arrows on traffic signs) as necessary. At the same time, to think about Emil's future path both **from the starting point** and **in the reverse direction from the destination**.

Computing-specific content

In the first and the third task, the pupils have to correctly understand, read and carry out a **program hidden on the stage** in the form of traffic signs with arrows. In the third task, they also have to add two missing steps in such a way that they look for the planned path both from the starting point and in the reverse direction from the intended destination point.

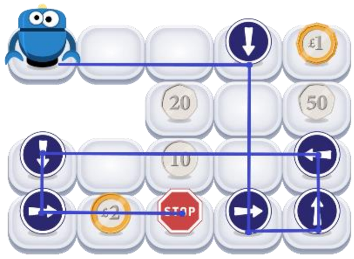
In the second task, too, the program for Emil is "hidden" directly on the stage, using a well-known "key" — the word **ABRACADABRA.** Thanks to the interesting structure of this word, there is not just one program hidden on the stage, but two (and there are two actual solutions to the task).

In the fourth task, the pupils navigate Emil on the stage so that he respects the given **criterion** and collects only the right objects — letters — into the tray.

Teacher support and commentaries

1

WB: Follow the traffic signs. Click on the arrows to guide Emil to the stop sign.
How much money does he collect on his way? Emil collected: ...



The traffic signs with arrows on this stage have an unusual function in this task: they are not supposed to be collected but used as indicators of the direction. We are to navigate Emil along each arrow, respecting the direction signs and arriving at the Stop sign. Therefore, we cannot change Emil's direction on any position except for those with arrows — that way, the "coded" route on the stage is quite unambiguous. Actually, to calculate the sum "collected" by Emil whilst following the path is only secondary.

2

WB: Use Emil to write the magic word ABRACADABRA on the shelf.
Find two solutions. ...

The word is obviously **ABRACADABRA**, laid out on the stage in such a way that there are precisely two solutions to how Emil can collect it. The pupils may explore and check their solution in task **X3**.

3

WB: Follow the traffic signs again.
Draw two missing arrows in the blank signs so Emil can find the treasure. And the treasure is the green pear!

We see a "road" situation similar to the one in task **after D1**. However, the pupils now have to study various directions from Emil's starting point and his potential destinations should the choose them and follow the set rules. If we chose the arrow under Emil as the first one, he would have to continue left and in the next position, he would need to go upward… becoming stuck at the sign **No entry — one-way road**. If we chose the first arrow to the right of Emil, he would have to continue upward and then to the left… to become stuck either at the parking lot or at the Stop sign behind him. This means that he has to go upward and to the left, finally arriving at the first place with a missing sign. This complicates the situation significantly. However, we know that he has to fly all the way to the pear, so let us take a look at his path both in the reverse direction from the destination and forward, starting at the missing sign. If the missing sign was a mandatory left turn, Emil would become stuck at the Stop sign. If it indicated a U-turn, he would become permanently **stuck** in the upper row, flying back and forth (permanently walking back and forth is an **interesting situation** in computing). The first sign must therefore be pointed downward. From there, he has to fly to the left and down again. Emil has to approach the treasure from the bottom side, meaning that the second missing sign must be a right arrow.

4

WB: This is Emil's stage. Start each task with all the letters.
Emil has to collect as many vowels as he can into the tray, and nothing else. Write the ones that he can collect.
Emil has to collect as many consonants as he can into the tray, and nothing else. Write the ones that he can collect.
Emil has to collect letters from the second half of the alphabet into the tray, and nothing else. Write the ones that he can collect.

This is another unit of three tasks for Emil that share the stage and starting point. In the first case, Emil has to collect as many vowels into the tray as possible. The pupils may realize that they cannot collect the letter **U** with Emil because it is blocked in the corner of the stage by three consonants. In the second task, they will probably succeed in collecting all consonants because Emil will gradually open up a path from the top to the “hidden” letter **T**. The pupils may explore and check their solution in task **X4** in the software, where we suggest that they create a similar task for others.

Group discussion

–Even in the case of the “after” tasks, there may be a situation when we wish to discuss the tasks with our pupils, asking about how they managed to complete them or to point their attention to certain interesting events in the tasks, among other things.

(task 1) *Who has drawn Emil’s path into the map in the workbook? How much did Emil collect on his path?* (£2.10)

(task 2) *Is it possible to collect the magic word **DACABRAABRA**?*

(task 3) *What would happen if we drew a left arrow in the place of the second missing sign? What would happen if we drew an up arrow for the second missing sign?*

(task 4) *Which vowel is impossible for us to reach with Emil in the first task? Why? How is it possible that in the second task, we successfully collect all of the consonants, including **R** or **T**? What is the difference between vowels and consonants? Which group is larger?*

Emil the Collector • E

Learning objectives

- To learn how to avoid unnecessary clicks (or touches if using a tablet) when looking for a path — **steps** or **moves**
- To plan Emil’s path with a new constraint: Emil **cannot return** to the position that was once marked by clicking (not as the target; he can still fly over such positions, though). To become accustomed to this constraint when solving problems in known situations (coins, letters).
- Work with the (as of now, only verbally) given **number of clicks** and, at the same time, to try to collect the largest possible sum into the tray. To accept another constraint (*no button*).

Computing-specific content

In this unit of tasks, the pupils will discover an important **constraint**: after clicking on any position, it turns grey and we can never click on it again. That said, Emil can still fly over such a position without any problems. The same applies to Emil’s starting position, which is coloured from the very beginning and contains Emil’s special sign. This constraint greatly restricts the search for paths on the stage and motivates the pupils to create “minimal“ solutions, i.e. to save clicks when navigating Emil, looking for **the longest and most efficient moves**.

In the final task of this unit, the pupils first meet another constraint, albeit only a verbally agreed one: they are assigned a **maximum number of clicks** to be used.

Teacher support and commentaries

E1

S: Follow the task in the workbook.
WB: Collect the numbers in the correct order.
Colour the positions which changed colour.

The pupils first think about the **correct order**, although they usually agree on the standard order of **1, 2, 3, 4, 5**. However, they may select **5, 4, 3, 2, 1** (or a different order if the pair presents a good argument for it — it may be completely random, or it may be e.g. **1, 3, 5, 2, 4** — first the odd numbers, then the even numbers). There is a solution for each of the three orders that we have mentioned here.

However, the newest addition is different: Each position on the stage that is clicked on by the pupils will turn grey and **it will not be possible to click on it anymore** —meaning that Emil will not be able to fly to that position again (and stop there). The same applies to the starting position — it has been grey since the beginning. It is important that the pupils discover that even if they cannot click on the coloured position, **Emil can still fly over such a position**. Therefore, they need to make an effort to click on as few positions as possible when collecting numbers (i.e. solving the problem), so that they do not block the positions which may be needed for later moves.

If clicking carefully and following the order from **1** to **5**, the pupils may finish the task with as many as 8 positions whose colour remains unchanged.

E2

S: Follow the task in the workbook.
WB: What good words can you collect? Start again each time.
With Emil we collected these words:

Similarly to task **C2**, the pupils have to decide upon the "good words" again. Unlike in task **C2**, though, the pupils must now carefully think about every move that they make with Emil so that they do not lose access to additional letters, if possible. These letters allow them to assemble dozens of words, from short words (such as **A** and **I**) to medium-length words (such as **RED, AID, HAY, HIM,**...) to long ones (such as **HUMORED, DAIRY).**

E3

S: Follow the task in the workbook.
WB: With Emil, collect as many coins as you can. Avoid the buttons.
Write down the amount you saved in the tray.

If choosing suitable places to click, the pupils may be able to collect all eleven coins, i.e. a total of £7.60, leaving only two buttons and a couple of uncoloured positions on the stage. However, any smaller number of coins is a good solution as well.

In the discussion, we should lead the pupils to help themselves when counting the total amount in the tray by dragging the coins around and grouping them like so: 20p + 20p + 10p. We consider the task to be solved if a coin remains on the stage, but not if the pupils collect buttons into the tray as well, because we are not supposed to collect buttons.

E4

S: Follow the task in the workbook.
WB: With only four clicks collect as much money as you can. Avoid the button.
Write down different solutions. What coins did you save and how much money did you save up?

This task adds a new constraint: the **number of clicks** or **touches** (on a tablet). For now, the pupils count the number of clicks themselves; however, starting with the **G** unit of tasks, they will have a new instrument available. Up to £3.20 can be collected with four clicks, but smaller sums — without coins — are considered to be correct solutions to the problem as well. It is important that the pupils think about a certain strategy, consider and explore various procedures and their consequences.

Group discussion

(positions are coloured, E1) *How did Emil's behaviour change in this task?* (the clicked position turns grey and we cannot click it anymore) *Who was able to colour (use up) the lowest number of positions? What order of numbers did you choose? Who completed the task using the number order **5, 4, 3, 2, 1**? What other orders can you suggest? Can we make a deal on the fact that even the order of **1, 3, 5, 2, 4** can be right sometimes? Can we name such an order?* (ascending odd numbers followed by ascending even numbers)

(E2) *How is this task different from task **C2**? Which two-letter words did you find? Which five-letter words? Who has found the longest word?*

(E3) *Did anyone collect five coins? Or six? Did anyone collect all of the coins? Which coin did you and Emil take as the last one? Those who collected all of the coins: which one did you take as the last?* (10p) *Would you be able to finish with a different coin (and still collect them all)?*

(limited number of clicks, E4) *Who saved the most? The task was about collecting as much money as possible, but let's change it: Which is the smallest sum of money that you can collect in four clicks?*

Emil the Collector • F

Learning objectives

- To work with another constraint — with a **partially predefined order** in which we need to collect the objects on the shelf.
- To see the shelf as a **set of objects with a certain structure** and with a recurrent rule. To discover this rule and adapt one's own solutions accordingly.
- To avoid redundant clicks.

Computing-specific content

In this unit of tasks, the pupils face another **constraint**: when collecting things, **some places on the shelf may be pre-set**, from one to several places (even all of them). At a given place on the shelf, the pre-set thing is visualized as its shadow. That way, we introduce the pupils to another interesting and important concept which we will explore and discuss more and more often later on — namely, certain **patterns** or **repeated groups of data**. Therefore, in addition to the order in which we have collected them, the things on the shelf may have a predefined structure (as can be seen in the second task, for example — the repeating group *apple, apple, pear*).

In tasks **F3**, **F4**, and **F5**, two or more shadows determine (suggest) the resulting structure of the whole shelf: either it consists of a numeric order or some elements of an equality. The pupils have to come up with ideas and set them up on the shelf in such a way that they respect the pre-set elements and manage to navigate Emil in a situation where his positions on the stage become coloured after clicking.

Teacher support and commentaries

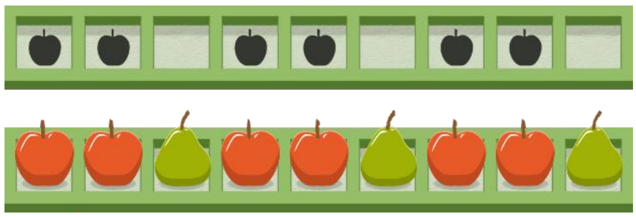
F1 ***S: Collect all the objects on to the shelf.***

The pupils may not notice at first that the second place on the shelf contains a **shadow that indicates the thing which Emil has to take in the second place**. However, they will certainly realize that something is wrong if they keep collecting shapes and take something other than the "prescribed" ball in the second place. Then (if not earlier), they will carefully examine the whole stage and discuss the problem. That way, the pupils will discover a new constraint, the **pre-set order of some things on the shelf**.

In addition, we still have the rule that each clicked position is coloured — preventing Emil from flying there (although he can still fly over it and collect things from the positions that neighbour the greyed-out position).

F2 ***S: Now fill up the shelf.***

The first task was only meant to introduce the pupils to a new kind of constraint — which, however, opens up a completely new class of interesting tasks with objects arranged in certain **recurring structures**. For example, this task provides an initial indication of the places on the shelf where apples should be placed:



As the initial stage contains a total of only six apples at the beginning of the task and their final places on the shelf are set, the complete structure of the shelf is thus determined as well (there are no more apples, which means that the empty places between the apples need to be populated by pears). Despite that, there are several correct procedures that make Emil reach that goal on the shelf and leave three different pears on the stage.

F3 ***S: Collect the numbers in the proper order.***

The correct order is **6, 5, 4, 3, 2, 1** because the numbers **4** and **3** must be placed on the third and fourth place on the shelf, respectively. If some pairs, however, come up with their own interpretation of what else could be the *correct order* and collect the things accordingly, we should show appreciation for their approach (e.g. a numeric "zigzag" of **1, 2, 4, 3, 5, 6** — the numbers go up, down, and up here). Either way, we need to insist on a justifiable order that can be explained.

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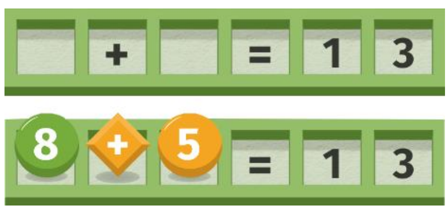
* **NOTE:** the following three tasks are rather difficult. We recommend that the teachers decide whether they want to work on them with the whole class or give the tasks only to some pupils that are looking for an additional challenge.

F4 ***S: Complete the sum.***

In this task, the pupils must find out which one-digit numbers create a sum of **13**. Then, they have to create such an equality with Emil.



The split of the number 13 may lead them to consider the pair of **9** and **4** —neither of these numbers is accessible to Emil, though. Therefore, only the pair of numbers **8** and **5** can be considered, leading to the equalities **8 + 5 = 13** or **5 + 8 = 13**. We have noticed that the pupils sometimes only arrange a part of the equality on the shelf, filling the shelf only up to the last empty place (see the figure to the right). Together with the shadows of pre-set objects, they consider the shelf "solved". However, they should realize (at least in the final discussion) that the task is not complete if solved this way.

F5 ***S: Complete the sum.***

This is a **more difficult variant** of the previous task. The pupils have to find out which number they are looking for and whether those number are accessible to Emil. Emil must most certainly start with the number one; then, the pupils should consider (or try), which of the options — **2, 5, 8** and **9** (i.e. numbers **12, 15, 18** and **19**) — might lead to the completion of this equality. We should acknowledge those pupils that find one of the following solutions: **15 – 9 + 2 = 8** or **12 – 9 + 5 = 8**.

F6 *S: Solve the task.*

The shadows on the shelf prescribe a complete final word — **COCONUT.** The difficulty of the task lies in the fact that it is crucial to take the right initial steps: the pupils need to guide Emil to the letter **C** in such a way that they can leave the "corner" and move to the third row, where they take the letter **O** and continue to the following letter, **C**.

Group discussion

(F1) *What is new in this task? What does the shadow of a thing in one of the places of the shelf mean? How should we approach this task if we want to place both apples at the very end of the shelf?*

(F2) *There are shadows of six apples shown on the shelf. What do we need to place between them? Could we place apples there?* (no, we don't have enough of them) *Did you manage to fill the shelf correctly? How many pears did you leave on the stage? Which ones exactly?*

(more demanding) *How many clicks did you need to solve this task (would eight be enough)? How do you count the number of clicks only after you complete the task?*

(F3) *Did you figure out that the right order is **6, 5, 4, 3, 2, 1**? How many clicks did you need to complete this task?* (it is impossible to use less than nine)

Extensions

(F2) One pupil tells another which of the pears will be the three that remain on the stage at the end. The task cannot be completed with some trios, though.

Emil the Collector • G

Learning objectives

- To acquaint themselves with a new way in which the task assignment sets the **maximum number of allowed clicks**.
- To realize that it is the first time that we create — and leave — **a record of Emil's path** on his stage. To copy the same record to the workbook.
- To realize that with certain constraints, we cannot complete the task to the full extent.
- To understand the style of assignments in task **G4** and to suggest similar assignments for classmates.

Computing-specific content

In the final task of the **E** unit of tasks, the pupils are familiar with the verbal constraint of the number of clicks — they were to collect the largest possible sum using four clicks only. Now, this constraint is an integral part of the assignment and Emil's stage: the pupils find out that the maximum **number of clicks** available is expressed by **number sticks** in the left corner of Emil's world. Every click on the stage will remove the first number stick, colour (and disable) the clicked position and **mark** it with the number stick bearing the ordinal number of the click. Thanks to that (and together with Emil's starting position), a **visible record of Emil's steps** is formed on the stage and we are subsequently able to read it, provide commentaries, analyse it etc. Given that the pupils copy the record to their workbooks, they can reproduce their procedures at a later time. The pupils thus start working with a symbolic record of their solution. We consider this to be a key step in their path toward programming.

The tasks in this unit require careful thinking and planning of steps as the clicked positions **cannot be marked as Emil's destination again** (although he can fly over them). At the same time, the total number of clicks is limited and the pupils should solve their own tasks — to collect as many pears as possible, as many letter pairs as possible etc.

Teacher support and commentaries

G1

S: ***Follow the task in the workbook.***
WB: ***With Emil, collect as many pears as you can.***
In the picture below, mark the positions you clicked on with the numbers 1, 2, and 3.
We collected ... pears.

The pupils find out how the on-stage step recording works and how the maximum click count is determined. We need to make sure that the pupils take note of the numbers **1, 2,** and **3** along with their positions on the stage — only this way will they be able to reproduce their procedures correctly in the final discussion. Another reason for the importance of this approach is the fact that it is the first time that the pupils see the creation of a record of their (or Emil's) steps in the Emil software environment.

This task also develops strategic thinking. As we only have three clicks at our disposal, we need to make the best possible use of every single move, not clicking on adjacent positions or only on the closest thing to be collected, but to click as far as possible in the given row or column so that we collect as many things as possible and prepare a good position from which we take another step. If the pupils still have not arrived at the "long move" strategy, they might collect only about three or four pears. Others may pick five or six of them.

The pupil might suggest that some pairs try and collect even more pears than what they had collected by then. *Could you collect seven of them?* When some of the pupils find out that they cannot collect seven pears in three clicks, make a suggestion that they think — and explain to others — how many clicks would be enough.

G2

S: ***Follow the task in the workbook.***
WB: ***Collect the same number of apples and pears.***
In the picture below, mark the positions you clicked on with the numbers 1, 2, 3, 4 and 5.
We collected ... apples and ... pears.

The pupils will try to collect as many apples and pears as possible, i.e. four apples and four pears (this is actually possible with Emil and there are several ways to do that). However, some of the pupils will not be able to collect four pairs. Some may also deliberately collect only one apple and one pair, or two apples and two pears. All of these solutions are correct — especially when we realize that there is no mention of the fact that we need to collect as many as possible.

Some pupils may misinterpret the instruction, collecting apples first and only taking pears afterwards.

G3

S: ***Follow the task in the workbook.***
WB: ***Collect as many identical pairs of letters as you can. Collect only pairs.***
Emil and I collected these identical pairs:

There are four letter pairs, namely **A, B, D**, and **O**; the pupils try to collect them into the tray and not to take any other letter. This task is difficult as it is not easy to find out that we simply cannot collect all four pairs in only five moves. For three letter pairs, the pupils will find various solutions. The difficulty of the task is elevated by the fact that the already-clicked positions are coloured (and therefore disabled).

G4

S: ***Follow the task in the workbook.***
WB: ***Emil is collecting buttons and coins into the tray. Pretend that he buys buttons this way.***
Direct Emil to buy: two buttons for 10p three buttons for 12p four buttons for 2p

Think up two similar tasks for friends:

Each of the three assignments of this task comes with several solutions, i.e. with several paths on which Emil can collect the exact number of buttons required, together with the given sum. In the final discussion, the pupils can present their solutions based on their records in workbooks, and to subsequently analyse and compare them. The second part, where the pupils themselves should create two more similar assignments for others, may also spark their interest. There is a plethora of possibilities for additional assignments, from the more simple ones to the more difficult ones. A number of suggestions: *to buy the most expensive button possible, to buy as many buttons as possible for 1p, to buy as many buttons for as little money as possible, to buy 4 buttons for 5p, to buy 6 buttons for 5p…*

It is important to let the pupils give their own assignments to other pairs —for example, two pairs may exchange their assignments and try to complete them.

Group discussion

(number sticks, G1) *What was new in these tasks? How do we know how many clicks we can use? Why are there numbers on the number sticks? How many pears were you able to collect? Which pair will show us how they navigated Emil? Did anyone collect all of the seven pears? How many clicks would we need? How would Emil have to move?*

(G2) *What is the maximum number of apples that can be collected to complete the assignment? Who has collected all four of them? What if we only used one click to collect an apple and a pear? Would that be a correct solution?* (yes, it would; the number of number sticks does not say that we need to use them all)

(G3) *Which letter pairs do we see on Emil's stage? Which letters should we not collect? How many pairs have you collected? Which ones? Will you show us the path you took?*

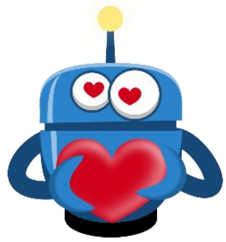
(G4) *Which of the three assignments did you collect? How much did one button cost Emil in the first assignment? What about the second one? What about the third one? What assignment did you create for others? Which one of them do you consider to be easy? Which one do you consider to be difficult? How many buttons can you "buy" for free?* (4 buttons) *What is the highest possible price for one button?* (14p) *Can you buy 5 buttons for 5p? And 6 buttons for 5p?*

Extensions

(G2) *Can we collect only one apple and one pear in five clicks? Or six? Or even seven?*
(G3) Let's try and collect only two given letter pairs: only **B** and **D**, only **A** and **D**, or only **A** and **O** (this is impossible) etc. Now, let's try to collect three given letter pairs: **B**, **D** and **O** or **A**, **D** and **O** (this is impossible).
(G4) *Did anyone find a solution for the first assignment (2 buttons for 10p) – where Emil takes only one 5p coin from the stage[5]?*

Emil the Collector • after G • Without computer

Learning objectives



- To strengthen knowledge and skills acquired when solving previous units of tasks when working without the computer (individually or in groups), especially when looking for a path for Emil with a limited number of clicks (a limited number of moves or steps).
- **To read and understand the record of Emil's path on the stage** and, according to the resulting content of the shelf, to deduce what path Emil took on the stage from the starting position, including the original layout of the things.
- To **consider various possible procedures** systematically and to choose the best possible solution from them (*how many pears can be taken with one, two, three… clicks*).

Computing-specific content

In the first two tasks of the unit, the pupils learn to **read and examine the record of a path** just **executed** by Emil, and to deduce, based on the path:

- his starting position on the stage — unambiguously marked by the position marked with his mark;
- **his precise movements on the stage** — from the start to number sticks **1, 2, 3**… etc.;
- **where and how the objects on stage were originally laid out** — if we see the resulting order of objects collected on the shelf according to the program. This is possible only thanks to the fact that Emil collected the objects **on the shelf**, allowing us to see which item was collected as the first, second… item.

In the third task, the pupils study the way how to control Emil if they have a limit of one, two, three… clicks whilst collecting the largest possible number of pears. In each of the assignment, they have to base their thinking process on the initial state — the original stage with 10 pears.

Teacher support and commentaries

1

WB: This is Emil's shelf after we told him where to go with five clicks.
Draw in the stage and answer: ...
Draw where all ones and zeros were in the field. (Remember: there is nothing where Emil starts.) ...

The starting position can be deduced easily; from that position, the pupils can draw Emil's path to number stick **1,** number stick **2**… all the way to number stick **5**. How many positions (except for the starting position) did he fly over? (It is over eight positions, excluding the final position). On the shelf, we see the order in which he collected the orange and red circles with numbers from the stage, thanks to which we can draw where the first, second… one was located. The only ambiguity is caused by the fact that the position marked by number stick **5** could contain the last thing — the orange zero. However, such solution would be difficult to draw for the pupils in the workbook and it is probable that they will not even consider it.

2

WB: We used six click and collected this shelf of numbers:
Draw where all the numbers were in the stage.

A more difficult variant of the previous task: The objects on the shelf and number sticks on the stage indicate that in the last column, Emil moved up and down as, among other things, he crossed the position with number stick no. **3** twice. The pupils must, therefore, think carefully about how to lay out the red and orange circles with zeros and ones, especially in the last column. Again, we do not expect that they would place the last one behind Emil in the final position; in that case, the task has only one solution.

3

WB: This is Emil's stage. Start each task from the start.
How many pears can you collect with one click?, with two clicks?, ...

The pupils should think about how to control Emil if the number of available clicks is limited and the task is to collect as many pears as possible. In fact, this is an extended variant of task **G1** and the pupils will have a chance to explore and check their solutions later in task **X5.** If we are planning to discuss the task with the pupils, we should certainly ask them about their strategy — what they thought about when working on the task. Two pears can be collected in one click (in two different ways), up to five in two clicks, up to seven in three clicks, up to eight in four clicks, and all of the ten available pears in five clicks.

Group discussion

(task 1) *How many numbers did Emil collect on the shelf? Can we draw or use a finger to show his path from the start to the finish? How many positions did he fly over? Where were ones located? What about zeros?*

(task 2) *How many positions did Emil fly over in this task? Can we draw or use a finger to show his path from the start to the finish? Did he fly over some of the positions more than once? What was the location of the first zero and the last one on the stage?*

(task 3) *What was the largest number of pears that you were able to collect in one click?* And in two? (up to 5 are possible) *How did you go? Why this way? Did you try a different path as well? How many did you manage to collect in three clicks?* (up to 7 are possible) *And in four?* (up to 8) *In five?* (all 10 can be collected)

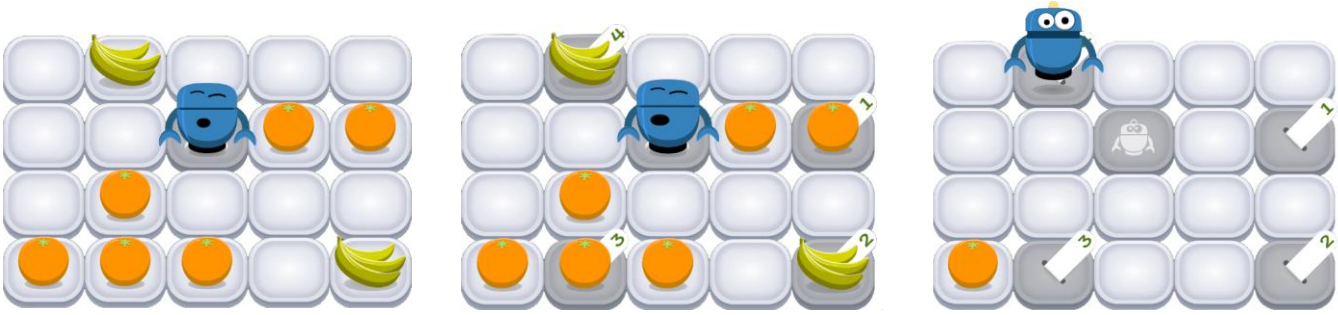
Emil the Collector • H

Learning objectives

- **To plan** the whole path for the sleeping Emil in advance, i.e. **to program** his path and only then wake him up, letting him **follow the program**.
- To combine this planning together with minimizing the number of clicks (moves or steps) and to think about the obstacles present on the stage.
- To consider the fact that **whilst carrying out the program**, Emil will **remove** some of the obstacles, which will stop obstructing the way in later moves.

Computing-specific content

In the tasks of this unit, we see Emil **sleep** for the first time. That way, he is letting us know that we will not navigate him directly along the path in the stage; instead, we will **plan the whole path in advance** — from the beginning to the end. Only after that do we wake up Emil by clicking to **follow** our **plan** or, better said, **program.** To plan his path, we will make use of the already-familiar number sticks, which we will "stick" into the positions on Emil's stage, one by one after each click. From the previous tasks, we know how the **maximum number of clicks**, i.e. **the steps of our program**, is determined.



In the series of pictures (according to task **H4**), we can see

- (left) the initial stage, the layout of objects and the position that serves as Emil's **starting** point;
- (middle) a **plan**, i.e. **program**, ready for Emil to follow. We see that it contains four number sticks with the numbers **1, 2, 3,** and **4** and their exact position on the stage;
- (right) the final stage after having woken up Emil, who **carried out** our program by moving along the path from one number stick to another, i.e. from the start to **1**, then from **1** to **2**, then to **3**, and, finally, to **4**. We also see how Emil finished and which objects were left on the stage (the remaining were collected on the shelf or into the tray). The picture thus allows us to identify Emil's starting position and his movement on the stage.

In the previous letter, we used the number sticks: they represented **a visible record of steps** we took when navigating Emil on the stage. Now, we are starting to use them as **the plan of a future path** for Emil.

Teacher support and commentaries

H1 ***S: Click on the numbers in order. Then wake Emil up.***

The aim of this task is to introduce our pupils to a new event — **programming** the sleeping Emil (and it is only secondary to collect the numbers on the shelf in the order **1, 2, 3, 4, 5**). Emil's initial sleeping state will be used in all three worlds to symbolize the fact that we need to program the whole path (the whole solution to the problem), and only wake up Emil afterwards to **carry out our program**. This execution is a certain form of a visual check of whether we correctly expressed (planned) the desired solution. This, however, is not real feedback. It is true that Emil will show (take) all planned steps; however, he will not tell us whether the plan and its execution represent the real solution to the given problem. The decision is still to be made by the pair that is solving the problem, or to be made at the class-wide discussion.

This task, too, allows us to discuss the exact meaning of the statement “to click on the numbers in the correct order”. If the pupils wished to do so, they can plan Emil’s path to collect the numbers in a different order, e.g. **5, 4, 3**…

When executing a pre-composed program, the pupils will be happy to use the **turbo mode** to speed up the execution; it is likely that someone in the class has already discovered this option in Emil’s world and the information about it has spread among the others. If not, we need to lead the pupils to its discovery in a discussion — but not to tell them right away, only pointing them in the right direction instead.

H2 ***S: What's the second biggest city in England?***

The pupils will only be able to plan (i.e. program) the path that composes the whole word **MANCHESTER** if they carefully apply the strategy of “long moves”. It will be easy for us to find out that the task has only one correct solution.

H3 ***S: A device that runs programs.***

This is a more complex variant of the previous task as the planning of the path requires the pupils to consider the fact that some of the obstacles (letters) will be collected by Emil in his first pass. This means that when Emil flies over a given position, the obstacle will not be present anymore. This applies to the letter **C** in the required solution **COMPUTER**: on his path to **O**, Emil will collect **C** as the first letter. If he then collects **M** and flies from **P** all the way to **T**, he will collect the letters **P, U,** and **T** one by one, but the letter **C** will not be in his way as **it will have been collected by then**. We consider the development of the pupils’ thinking in terms of **dynamically-changing conditions** on the stage to be an important computational skill.

If, during the execution of the program, Emil encounters a step that he **cannot perform** (such as flying in diagonals or flying over a missing position), he stops and signals a problem to us.

H4 ***S: Collect as much fruit as possible.***

When solving this task, the pupils will utilize and develop their strategic thinking and planning — there are only four clicks (moves) available to us, which is why we need to make effective use of every single one of them.

They will try out various procedures, but they will soon find out that they cannot collect all fruit. How much fruit will be then left on the stage?

H5 ***S: Collect only the zeros.***

A quite difficult task which requires careful planning of every move: as there is a limited number of them, each move needs to be as “useful” as possible in terms of solving the problem and positioning Emil well for the following step. We have found three different solutions; however, all of them start with the same first move (see right).

Group discussion

(H1) *What do we need to do before waking up Emil? Why do we need to wake him up? How does he know what to do? If we plan a path for Emil like this…* (we plan the path between **1, 2**… in front of the pupils)*, who can tell me, step by step, how Emil will move and in what order he’ll collect the numbers on the shelf? What will Emil do if he wakes him up before planning the path? Has anyone found out what the lightning button is for?* (Emil moves faster)

(path planning, H2, H3) *Has anyone put together the word **MANCHESTER**? Did you have enough steps? Could you do that with fewer steps? How do you call Emil’s home in English? Who has composed the word **COMPUTER**? When Emil goes from **P** through **U** to **T** (fourth step), will the letter **C** be in the way? If not, why? In the town of Loonyville, they call a computer **CUPMOTER**. Can you compose a word like that, too?*

(H4) *How much fruit did you collect?*

(H5) *Did you manage to plan Emil’s path in such a way that he took all of the zeros (and nothing else)? Where did you place the first number stick, number **1**?*

Extensions

(H2) *Can anyone plan Emil’s path so that he spells the word **MANCHESTER** backward?*
(H4) *Suggest a procedure for Emil that helps him collect both bananas and only two oranges. Would you be able to solve the following problem: to collect all of the oranges and nothing else?*
(H5) *Solve the following variant of the task: Emil should collect all ones but no zeros. How many clicks will he need? Extra challenge: to collect all ones and the same number of zeros.* (to construct a program that will collect all ones and the same number of zeros in six clicks is really difficult, albeit possible)

Emil the Collector • after H • Without computer

Learning objectives

- To strengthen the knowledge and skills from the previous units of tasks when working without computer (individually or in group). Key skills include **reading and understanding the prepared plan** (program) for Emil and **planning his path**.
- To deduce, whilst reading Emil's program, the resulting content of the tray or shelf.
- To deduce, whilst reading and executing (only theoretically) Emil's program, the change of the state of the original stage, i.e. which objects will remain and which ones will disappear.
- To deduce, based on the program and the resulting shelf content after its execution, the original stage location of the objects.

Computing-specific content

In the previous unit **H** the pupils started planning their paths in advance and only let Emil carry out the plan (program) at the very end. This helped them to strengthen their perception of the **program as a record of the steps** being executed by Emil, and their perception of the **program as a plan of Emil's future steps**. One of the main general objectives of computing education at school is to learn how to **think** about such plans; in addition to their planning and execution themselves, to read them, explore them, execute them in one's head or on a piece of paper, to study their features etc. This is related to the situations when the pupils are to **read the program expressed on a piece of paper**, to execute it and then to deduce the final situation on the stage and in the tray or on the shelf.

In the tasks of this unit, the program is expressed by the picture of Emil's stage, or, better said, by Emil's starting position and several number sticks laid out on the stage. Given that, in addition to the program itself, we see the layout of the objects on the stage, these tasks allow us to think about the resulting content of the shelf or tray based on the execution of the program.

In task **after H7**, the pupils develop their skills in planning Emil's path when we know what is the content of the shelf that Emil has to collect. In the four assignments of task **after H9**, we ask the pupils a series of questions about how many objects will be collected by Emil according to the given program, which object will appear in the sixth place on the resulting shelf, and, finally, what the original layout of objects on the stage was if we can see what kind of a resulting shelf was produced by the program.

Teacher support and commentaries

This unit of tasks represents a useful **tool for teachers to provide formative assessment** to the pupils. The tasks summarise and combine various events and concepts that were gradually introduced to the pupils in the first world. The majority of the tasks is focused on the **reading and execution of the program**, which is expressed as a combination of Emil's starting position and the placement of number sticks. By reading and executing the program, the pupils are to deduce the resulting content of the tray, the last thing taken by Emil, the objects that remain on the stage, the content of the shelf etc. In task **after H7**, they are to look for various possible paths that will allow Emil to collect the prescribed years. The fourth assignment in task **after H9** requires that the pupils think backwards: they see the resulting shelf and the program on the stage, and are expected to reconstruct the original layout of the objects on the stage.

1

WB:* *Emil is buying buttons again. Mark the tray Emil will get with this program.

The pupils need to read the program, indicated by Emil's starting point and number sticks, carefully, drawing his planned path on the stage using a pencil and deciding which of the three possible "purchases", i.e. results in the tray, we can achieve. It is important to make the pupils realize that when moving from **3** to **4**, Emil will only collect two buttons and 7p — he will have already collected the middle button by then. Emil will thus "buy" four buttons and 14p.

2

WB:* *What words is Emil going to make with these programs?

First word: ...

In all three assignments, Emil has the same stage and starting point, but moves according to a different program. With the pencil in their hands, the pupils should slowly and carefully draw Emil's path and use the line on the side to write down letters as they collect them: **L** – **U** – **T** – **O** –... Someone might be so bold as to decide that he or she reads the program in the head only, spelling out the complete word at the end.

The pupils will have a chance to explore and test their solutions in task **X6.**

3

WB:* *Which letter will Emil get first and last?

Again, this task involves reading a program indicated by number sticks and Emil's starting position. We might notice quite easily that **B** will be the first letter to collect. However, it is more difficult to decide which letter will be the last to be collected as Emil go through several positions on his way from **4** to **5, 6** and **7**, which will, by that time, have been emptied. The last one will be the letter **I**, collected at the end of Emil's move from **4** to **5**.

4

WB:* *Which letters will be left after Emil's collection?

The task is similar to task **3**, but this time, we are focusing on the letters that remain on the stage after having executed the program. The pupils might use various forms of notation when working on this task. Preferably, they should execute the programs in pencil and draw Emil's progress on the stage. Only those letters that were not crossed out by any move will remain on the stage.

5 ***WB:*** ***How many buttons and how much money will Emil collect with these programs?***

Again, this task revolves around the reading of the programs and it is desirable that the pupils draw Emil's path, realizing the coins that are to be counted and the buttons that Emil will pass through. Alternatively, the path drawing may help the pupils realize which coins and/or buttons will be left untouched by Emil — counting only the remaining ones.

6 ***WB:*** ***What sum will Emil make on the shelf? Write it down and solve it.***

Another task to read the on-stage programs. This time, the result is a numeric expression that Emil collects on the shelf whilst walking along his path. The pupils are meant to write it down in the cells of the table and to calculate it afterwards. The first expression will be **4 + 5 – 8 + 3** (not **4 + 5 – 8 + 5 + 3**), the second will be **3 + 5 + 8 – 4** (not **3 + 5 + 8 – 5 + 4**).

7 ***WB:*** ***Put together different years on the shelf. Start the task again each time.***

Can you program Emil to collect these years?

The pupils are looking for various possible sets of four numbers, i.e. years. The fact that the starting position is already grey indicates that we will not be able to click on any position more than once. That is why it is impossible to collect, say, the year **2201**. Other (simpler) reasons prevent us from collecting **2020** as well (However, it is possible to collect **2800**.)

8 ***WB:*** ***This is Emil's program.***

How many zeros will he pick up? How many fours will he pick up? How many ones will he pick up? How many threes will he pick up?

The pupils read and execute programs and count the number of objects collected by Emil in each assignment.

9 ***WB:*** ***These are Emil's stages with programs. Follow each program carefully and answer the question.***

How many twos will Emil pick up? How many pears will be left? Now Emil is putting the numbers on the shelf. Mark in the stage which number five will end up in the sixth place. Draw the numbers in the stage where they were picked up from.

The assignments are similar to the previous ones: in the first one, we are to count the number of objects collected by Emil; in the second one, it is the number of remaining objects; in the third assignment, we are asking about the sixth thing that was collected; the fourth assignment asks to place the objects back on the stage correctly.

Group discussion

(executing the program on the paper) *How did you find out what Emil took to the shelf or placed into the tray? Did you draw his path? How are the collected objects and those that he left on the stage different?* (only those things will remain in their positions that do not have a line drawn through them) *Which names of cities did Emil collect in task **2**? Did you calculate the sums that Emil picked up in task **6**? What result did you get?* (**4** and **12**) *Which years did you program in task **7** and which are impossible to get? How many zeros did Emil leave on the stage in task **8**? How many fours? How many ones? How many threes? Would it be more difficult to solve these problems without drawing, in silence?*

Extensions

(task 7) *Find as many different years as possible. Don't forget that the positions get coloured after clicking and Emil can't go back to them. Can you also collect a year starting with 22?*
(task 9) *If, instead of **987654321**, we'd get the letters **ROBOTEMIL** on the shelf, what would Emil's stage look like in the beginning?*

Emil the Collector • X

Learning objectives

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

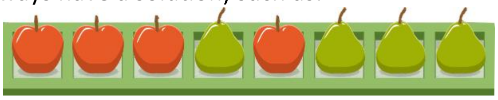
Computing-specific content

In these extensions, all computational skills, concepts and constraints presented in the first world are summarised. 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:*** ***Solve task 2 on page 3 of the workbook. Then design similar problem and give it to your partner.***

The pupils can check whether their ideas from task **after A2** were correct. We suggest that they create a similar assignment for their neighbours. They may try various procedures to collecting objects and might discover new and interesting variants (that may not always have a solution) such as:



X2 ***S: Solve task 3 on page 4 of the workbook. Then design similar problem and give it to your partner.***

The pupils can check whether their ideas from task **after A3** were correct. Again, we suggest that they create a similar assignment for their neighbours. They may try various procedures to collecting shapes and might discover new and interesting variants such as:

Can Emil collect everything except circles into the tray?
Can Emil collect only squares and nothing else into the tray?
Can Emil collect all shapes that are not squares into the tray?

X3 ***S: With Emil collect the magic word.***

This is task **after D2**. The word that we are looking for is clear — **ABRACADABRA.** Given its peculiar structure, there are two ways to collect the letters in the right order.

X4 ***S: Solve the task on page 9.***

Other similar tasks may focus on different (not only grammatical) events and features of letters of the alphabet. Here are some options:

Emil has to collect all red and blue letters, but nothing else
Emil has to collect all letters from the second half of the alphabet, but nothing else
Emil should collect as many letters from the middle of the alphabet as possible. (with this kind of assignment, it is good to decide — and agree — upon the middle of the alphabet, its second half etc.)

X5 ***S: Solve task 3 on page 12.***

Let us only repeat the commentary to the task **after G3** that two pears can be collected in one click (in two different ways), up to five in two clicks, up to seven in three clicks, up to eight in four clicks, and all of the ten available pears in five clicks. If the teachers have an opportunity to do so, it might be beneficial to talk to the pupils about how they think when working on this task, how they look for the solution and how they make sure that it is impossible to get more pears with the given number of clicks.

X6 ***S: Collect various names of the towns. Each time start again.***

This is task **after H2**. However, we see some pre-planned programs prepared using the number sticks. The pupils might open their workbooks on page 13 or they might simply notice some of the names of cities among the letters on the stage. Perhaps they will discover another city on the stage (a real one or one that “sounds right”)?

X7 ***S: Collect as many identical pairs of letters as you can.***

This is a more difficult variant of task **G3.** There are five letter pairs on the stage — **A, D, E, M, O**. Will anyone succeed in collecting at least four pairs? Or even five pairs? Will anyone successfully collect four pairs including the letter **D**?

X8 ***S: Collect as much fruit as you can but put all the apples next to each other.***

Therefore, we need to collect the fruit on the shelf in such a way that the three apples “sit” next to each other. It is a real puzzle and a rather demanding task; however, it is not without a solution — we can, say, collect four pears on the shelf, followed by three apples (a solution that fulfils the assignment), four pears followed by three apples and a pear (another solution that fulfils the assignment) or even five pears followed by three apples and a pear — only one pear will be left on the stage. Will anyone successfully collect all fruit whilst keeping all three apples next to each other?

X9 ***S: Collect everything.***

This task has several solutions which lead Emil to correctly filling the whole shelf. He might either go left or down…

X10 ***S: Collect everything in the proper order.***

Let us assume that the pupils will consider the descending progression of **9, 8, 7…** to be the correct order. When planning their path, they will have to consider each click carefully so that they can secure the best possible position for Emil’s subsequent moves.

X11 ***S: The second largest city in England backwards.***

The pupils might write down **MANCHESTER** on a piece of paper, perhaps even writing from the right to the left, planning how to use as few moves as possible to spell the word **RETSEHCNAM.**

X12 ***S:*** ***Put together a correct sum.***

The pupils may figure out that the only equality that corresponds with the pre-indicated places on the shelf is **7 x 2 + 4 = 18**. However, planning its construction on the shelf is more difficult due to the limited number of available clicks.

X13 ***S:*** ***Put together a correct sum.***

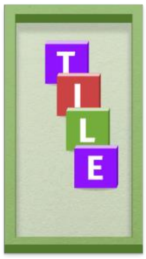
The pupils may calculate the right side of the equality, **2 x 7 – 5 + 1**, first, and only then will they follow by planning the path that constructs it. Given the constraint regarding the number of clicks, they will have to put a lot of thought into the solution.

Extensions

(task 1) *Can you suggest such a procedure for collecting apples and pears that will allow as many apples as possible to be located at the end of the shelf?*

(task 2) *Come up with a task that will result in exactly three objects being placed in the tray. Then, try a different task that will end with four objects in the tray. Then five, and then six.*

(task 3) *On the shelf, assemble a word in such a way that consonants and vowels alternate in it.*



(task 4) *If we collect letters of a word into the tray, such as **I, T, L,** and **E**, we can then order them correctly in the tray (perhaps in a column), making a word — **TILE**.*

*Can you collect the letters of the words **TRIBE**, **RATED**, **LITER** into the tray? Find the longest possible words.* (some examples: **TAMBOURINE**, **ROUNDTABLE**, **TIMBERLAND**, **RUDIMENTAL**, ...) *Find out if you can collect the letters of the word **RELOAD** into the tray. Would you be able to spell other good words using the letters in the tray?* (some examples: **ORDEAL**, **LOADER)**

(task 5) *If we only had one move, where would Emil be able to fly?* (four different positions in the first column or three positions in the first column, i.e. one of seven positions) *And a different task: Now, we can use two moves. Plan Emil's path in such a way that he flies over as many positions as possible.*

(task 6) *Find out which of the fictitious city names can be spelled: **BRINODUS**, **SINTUL**, **BRUSTOL**, **BRUTON**, **LONDUS**, **DUBLIN**.*

(task 7) *Which letters on the stage have no pair? If you could only collect vowels, which pairs of letters would we be able to collect?*

(task 8) *How do we need to navigate Emil so that all three apples sit next to each other on the shelf? What is the smallest number of pears that we need to collect so that all three apples can be next to each other on the shelf?*

(task 9) *This task has several solutions. Find as many as possible.*

(task 10) *Find a solution that places as few number sticks as possible on the positions with numbers.*

(task 12) *Could they also create an equality on the shelf that is not true?*

(task 13) *Could they also create an equality on the shelf that is not true?*