

Escape Games in STEM Education

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CANYOU
ESCAPE?



Structure

Part I: Using Escape Games in STE(A)M education

1. Why should we use Escape-Rooms in STEM-education?
2. The structure of an Escape Game
3. Learning by doing (part 1): Playing an Escape Game

Part II: Producing Escape Games

1. The structure of an Escape Game
2. Learning by Doing (part 2): Develop a digital Escape Game puzzle
3. Geogebra Books as basis for digital Escape Games

Outlook: Escape Games as a student project

1. Outlook 1: Creation of Escape Games in class
2. Outlook 2: Hybrid Escape Games
3. Homework

Addendum (not to be covered in this course but accessible for self study)

1. Literature
2. More digital Escape Games
3. An Introduction to coding with Geogebra

Part I: Using Escape Games in STE(A)M education



Introduction

What we intend to do:

- Why escape rooms?
- As simple as possible to implement
- Inspire

What we do not intend:


- A comprehensive introduction to Geogebra or programming basics

Escape Room – Basic Example of a task

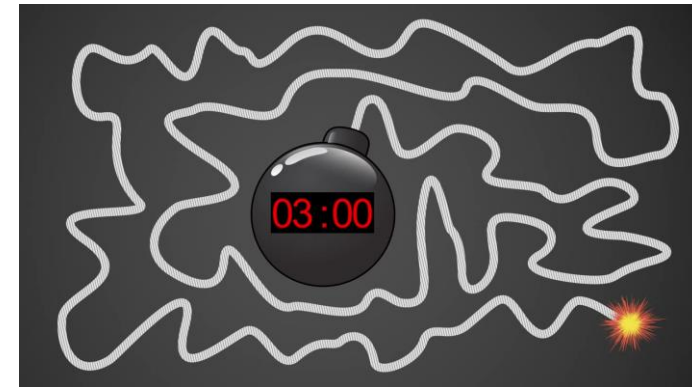
Can you escape?

Crack the code!

Hint 1: 682 - One digit is correct and in the right place.
Hint 2: 614 - One digit is correct but in the wrong place.
Hint 3: 206 - Two digits are correct, but both are in the wrong place.
Hint 4: 738 - No digit is correct.
Hint 5: 780 - One digit is correct but in the wrong place.



#MeetMissMathe



Why Escape Rooms?

combinatorics

KOMBINATORIK

3 Stühle, 10 Menschen, wie viele Kombinationen sind möglich?

→ ohne Beachtung der Reihenfolge
→ ohne Zurücklegen

Formel: $n \cdot (n-1) \cdot (n-2) \cdot \dots \cdot (n-k+1)$

$n = 10$ Personen
 $k = 3$ Stühle

$10 \cdot 9 \cdot 8 = 720$ ✓

Beim ersten Stuhl gibt es 10 Möglichkeiten
nur noch 9 Möglichkeiten
nur noch 8 Möglichkeiten

$(10 - 3 + 1)$
↓
8

Ein Zahlenschloss mit 5 Stellen & jede Ziffer ist unterschiedlich wie viele Möglichkeiten gibt es?

→ Mit Beachtung der Reihenfolge
→ ohne Zurücklegen

$n = 10$
 $k = 5$

$10 \cdot 9 \cdot 8 \cdot 7 \cdot 6 = 30240$ ✓

(10 - 5 + 1)
↓
6


Es gibt 30240 Möglichkeiten.

Can you escape?

Crack the code!

Hint 1: 682 - One digit is correct and in the right place.
Hint 2: 614 - One digit is correct but in the wrong place.
Hint 3: 206 - Two digits are correct, but both are in the wrong place.
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Hint 5: 780 - One digit is correct but in the wrong place.

#MeetMissMathe



Why Escape Rooms?

- Puzzles intrinsically motivate
- Fosters interest in STEM topics
- Everyone contributes to the solutions in their own way. Many skills and interests play a role
 - Skill
 - Logical thinking
 - Creativity
 - Linguistic skills
 - Mathematical and scientific skills...



Escape Activities

- Many different options to realize an Escape Activity („traditional“ Escape Room, City Challenge,...)
- As we are focusing on „STEM in a digital era“
 - closer look at digital Escape Rooms



Task (Test an Escape Game): 40 minutes

1. What needs to be done to "escape" from the room?
2. How do digital and analog puzzles contribute to the final "lock"?
3. How must puzzles/tasks be structured so that they can be used in an escape room?
4. Addition: Try to visualize the structure of the escape room graphically.



Now it's your turn: Try to escape



- <https://icse.eu/digital-escape-room/>

Discussion

1. What needs to be done to "escape" from the room?
2. How do digital and analog puzzles contribute to the final "lock"?
3. How must puzzles/tasks be structured so that they can be used in an escape room?
4. Addition: Try to visualize the structure of the escape room graphically.

Part II: Producing Escape Games



When should you use an Escape Game in STE(A)M-Education?

Escape Games can be used...

1. In case of declining motivation (short before Christmas, before summer holidays)
2. For exceptional events (teambuilding)
3. In projects (students build their own escape game)

Escape Activities are **not made for day-to-day** teaching

What do you need for an escape room?

- Structure
- Puzzles (STE(A)M Tasks, logicals ...)
- *Optional*: Background story (including sound, graphics...)

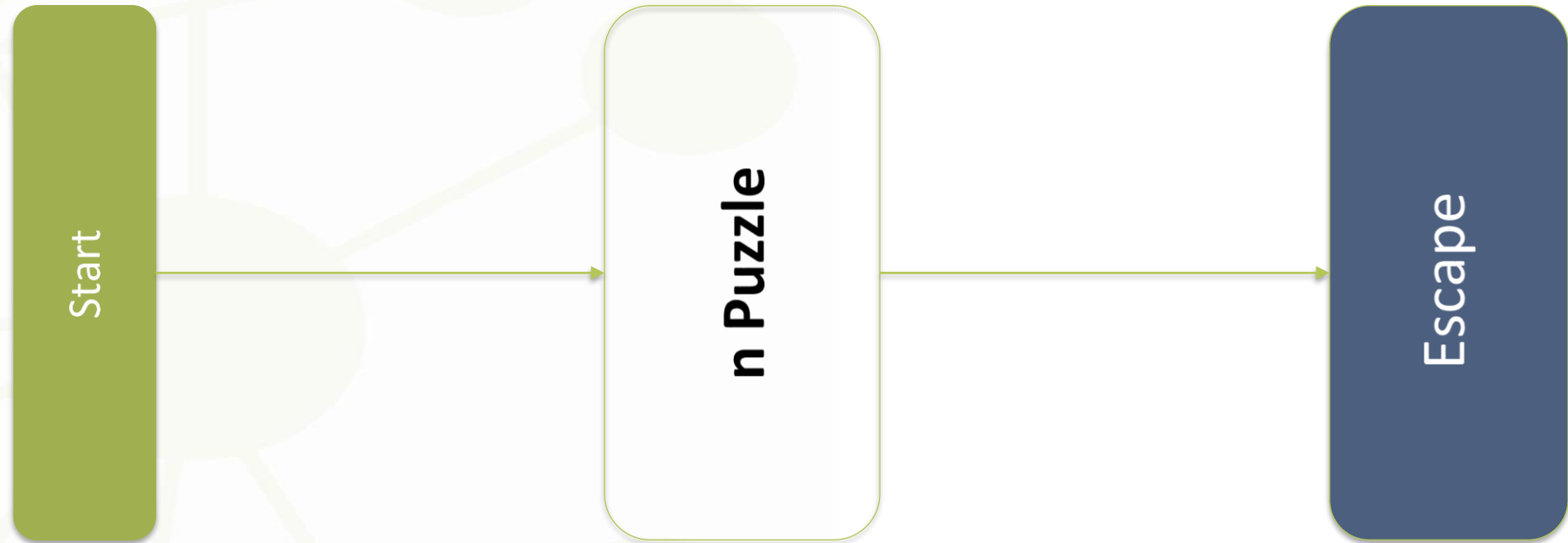
You will learn now

1. ...how to structure an Escape Game
2. ...how puzzles are characterized
3. ...to produce a digital puzzle yourself
4. ... how to develop a digital escape game (Homework is completion)



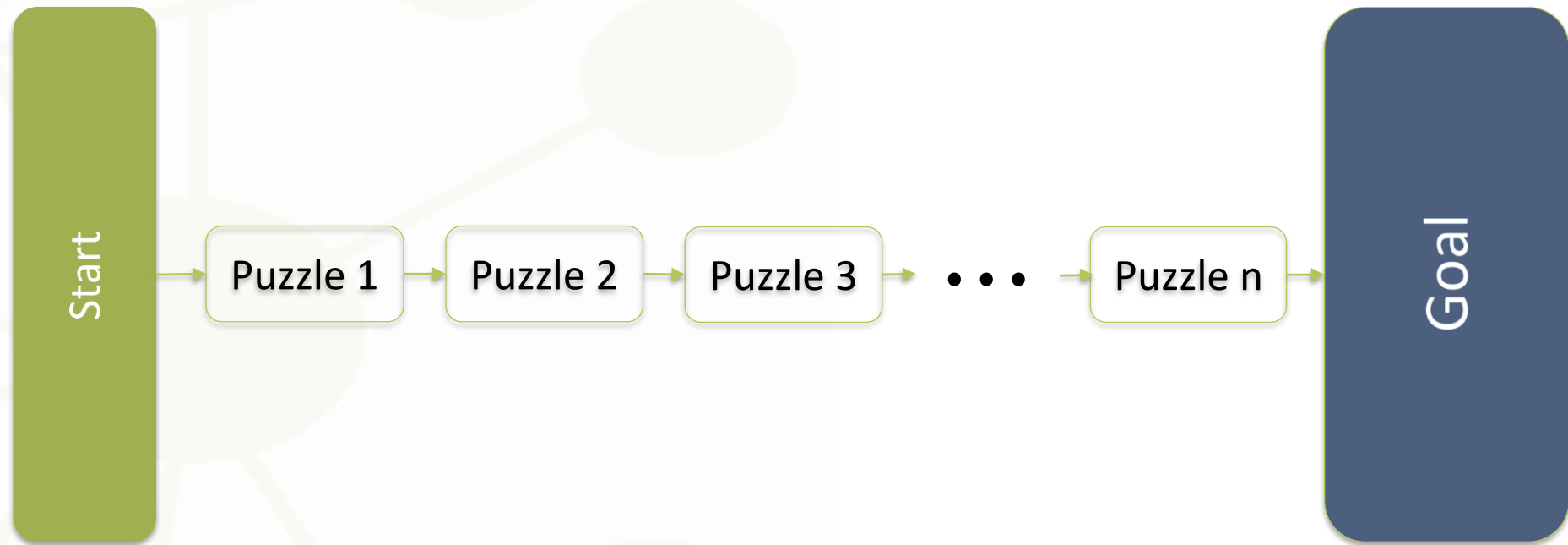
Structure of an escape room

Basic principle



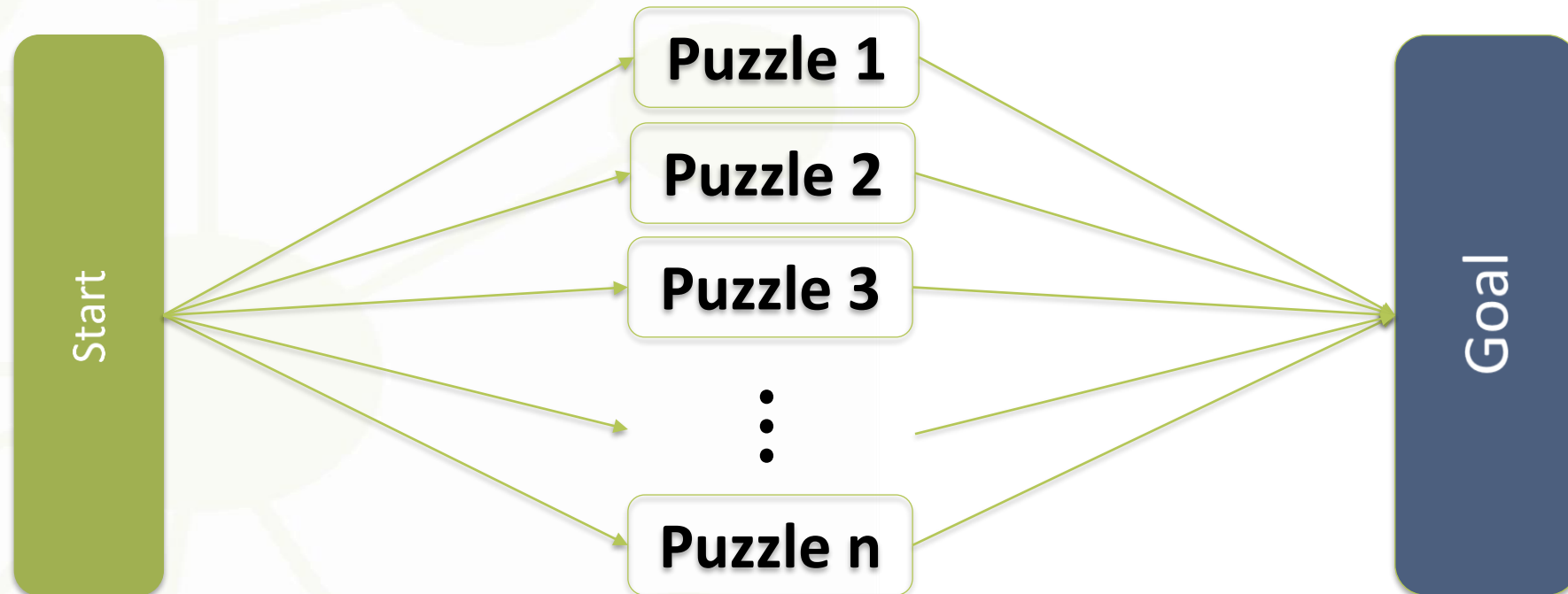
Structure of an escape room

Example 1: Type *Teachers* gives one task after another



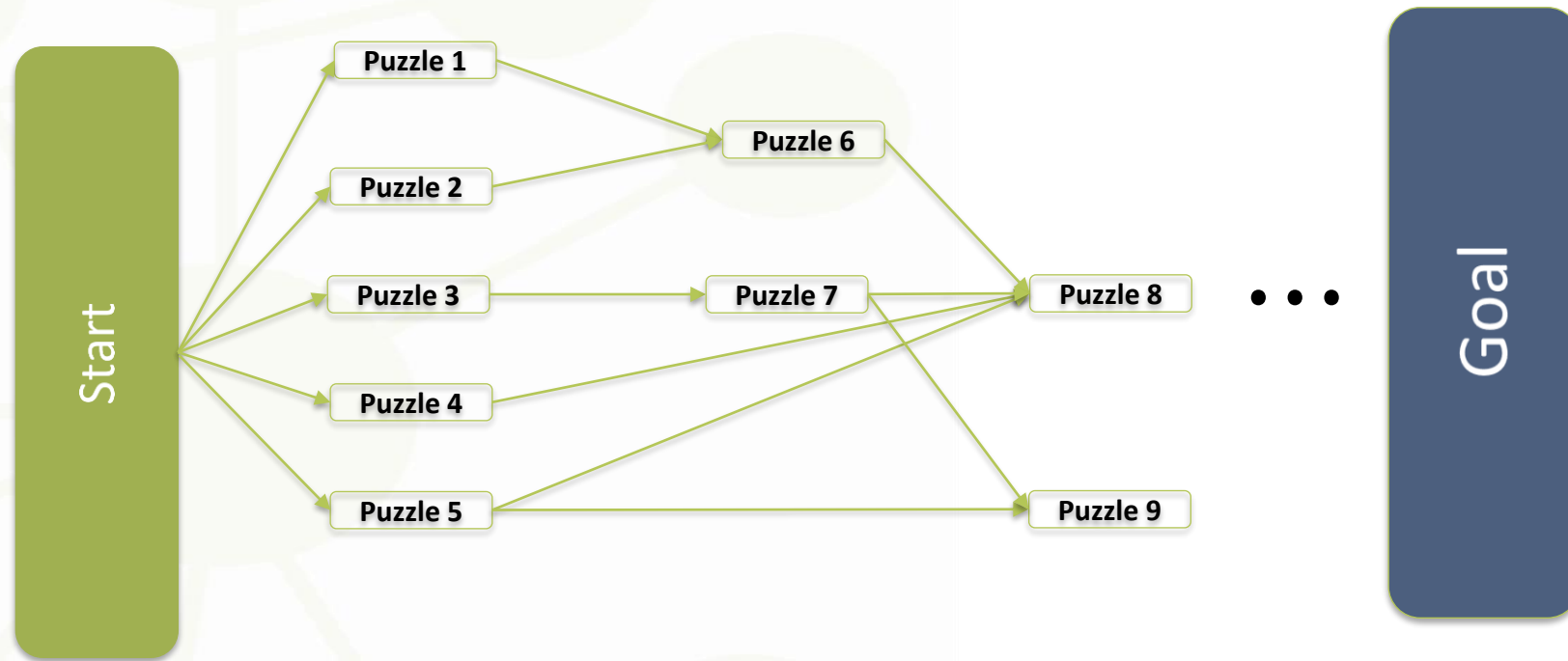
Structure of an escape room

Exampe 2: *Top grade in an exam*



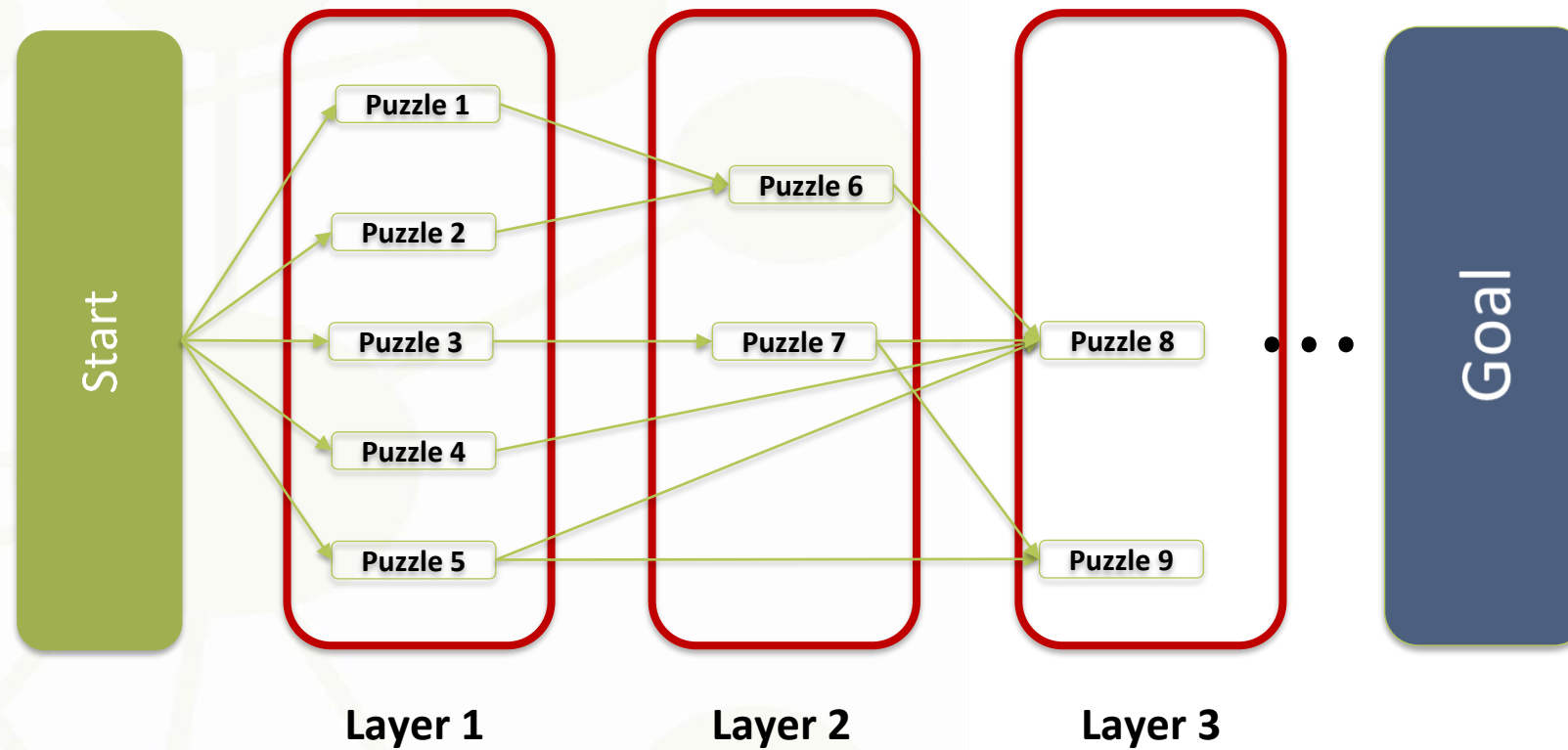
Structure of an escape room

Example 3: *General Case*



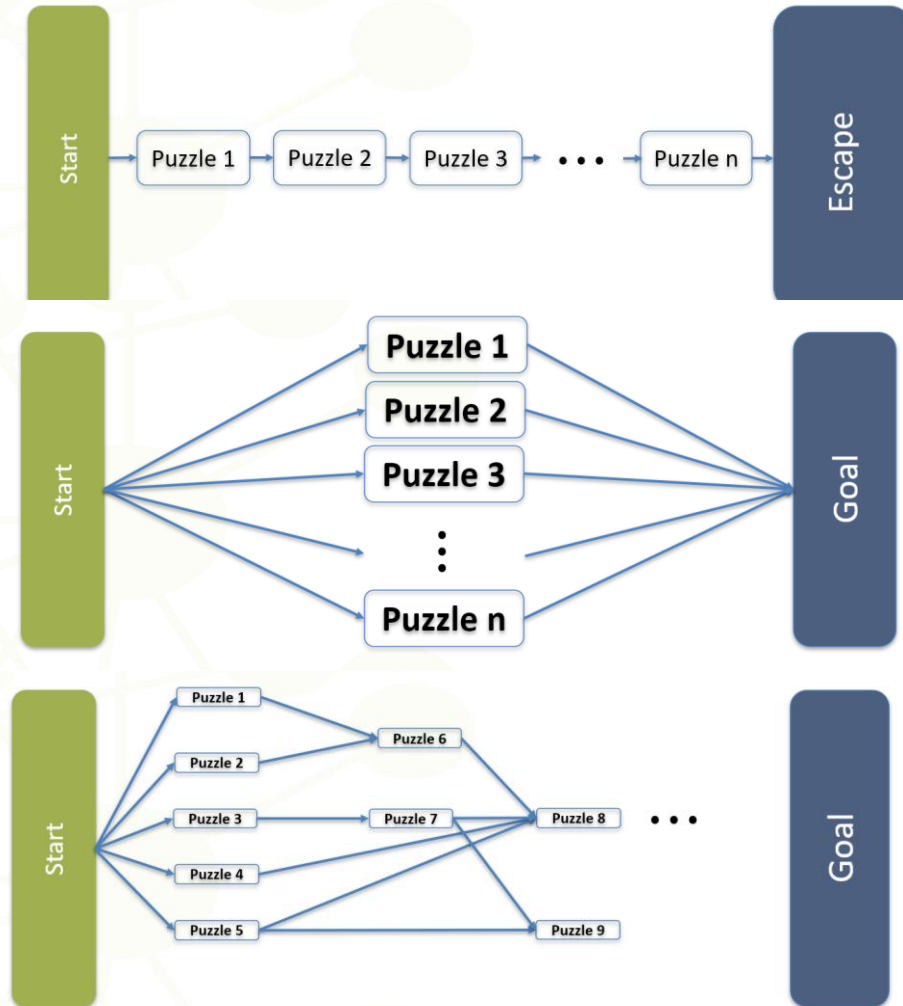
Structure of an escape room

Example 3: *General Case*



Structure of an escape room

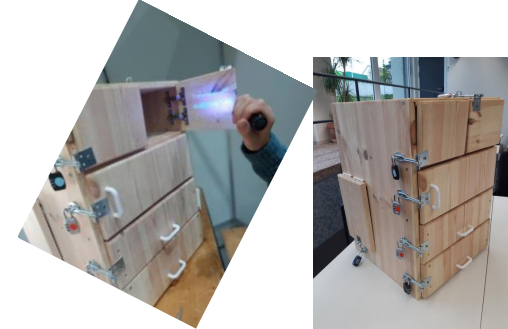
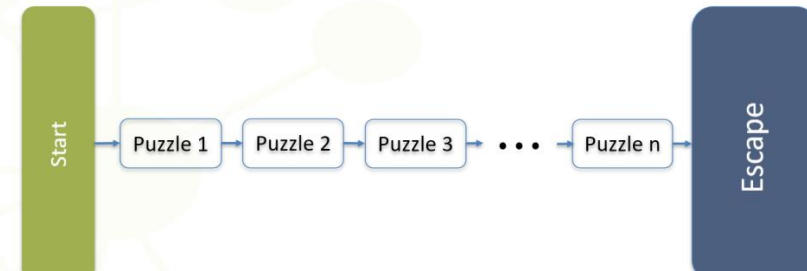
Can you imagine how Escape Activities with structure 1 & 3 might look like?



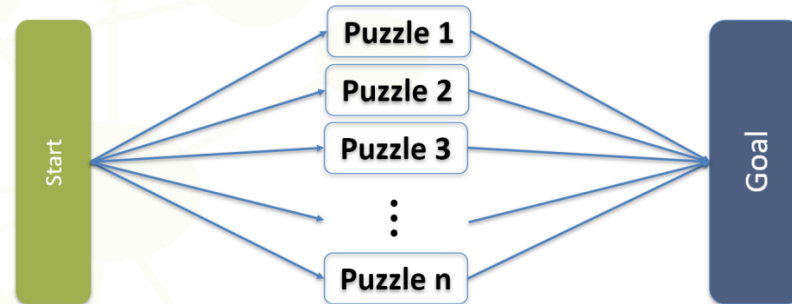
What was the structure of the digital escape room?

Structure of an escape room

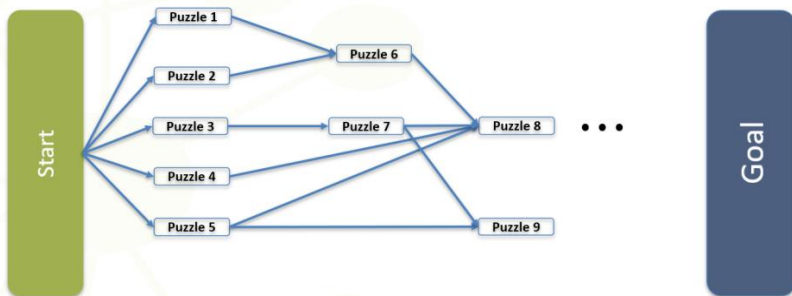
„Escape Box“



digital
Escape Room

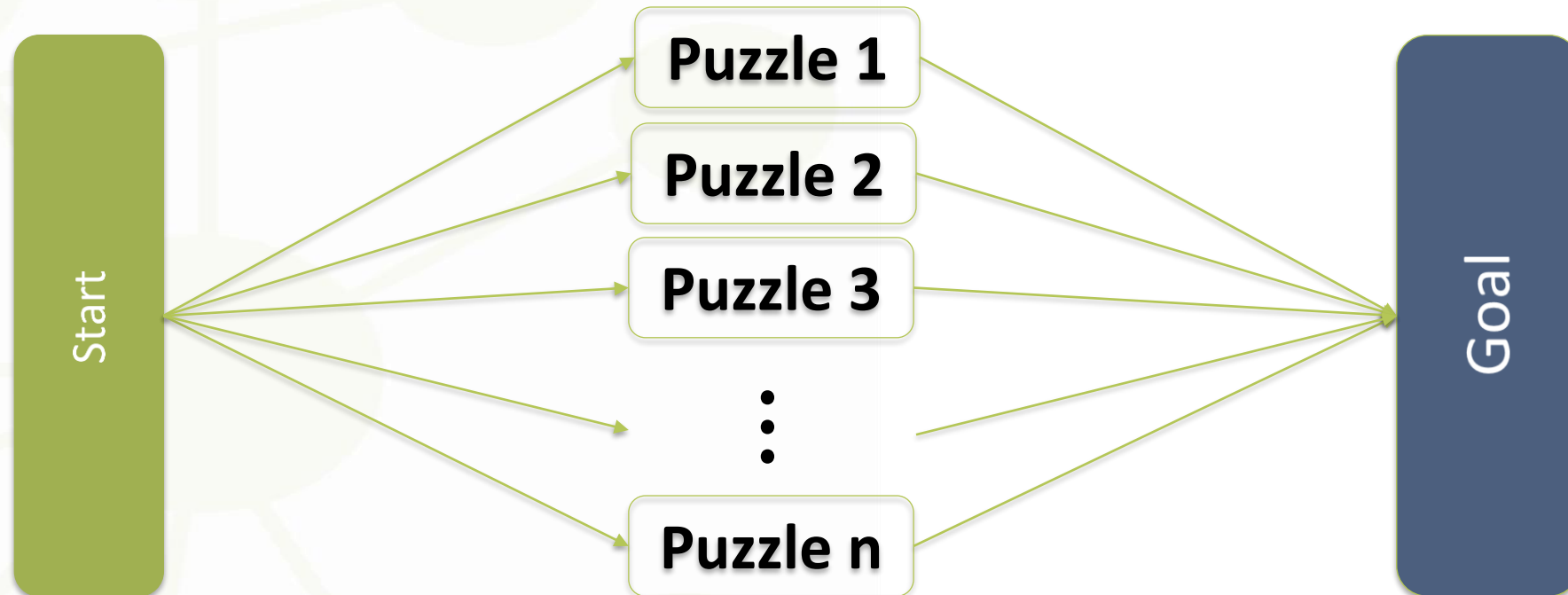


Physical Escape
Room

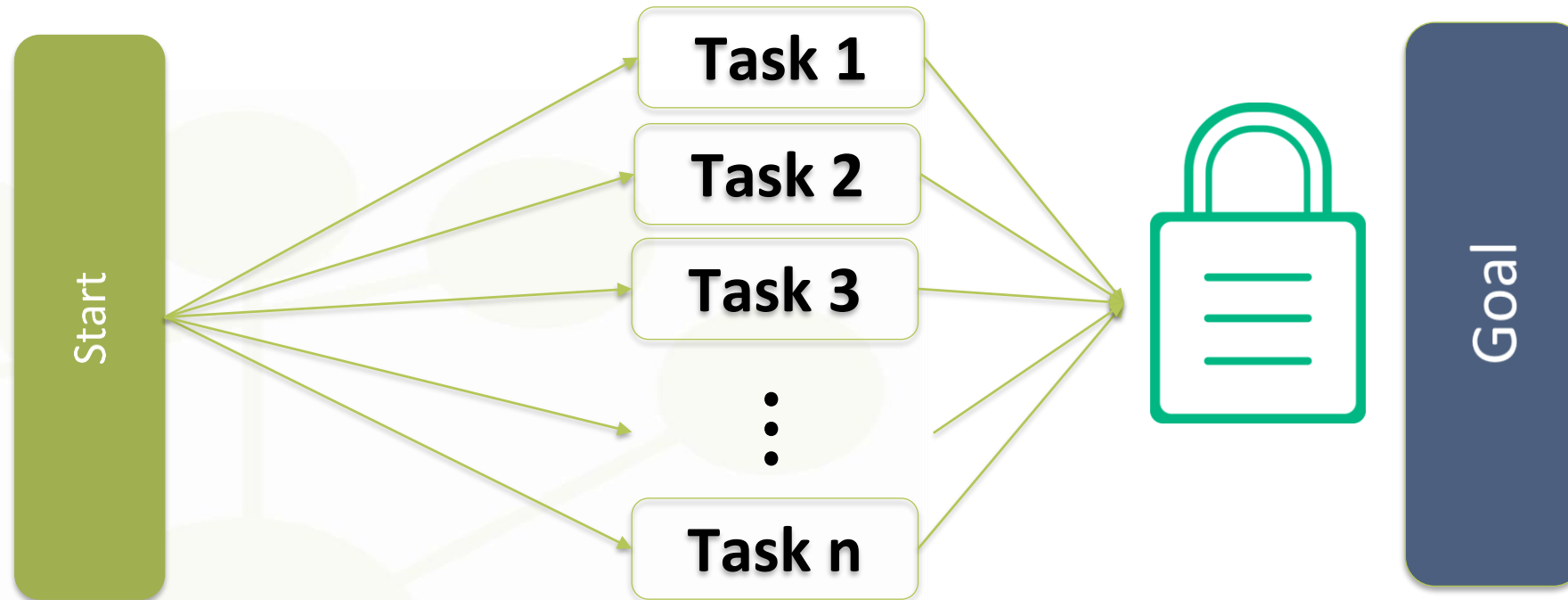


Structure of an escape room: the digital escape room

Example 2: The generic case



Structure of an escape room



We need:

- n puzzles -> solutions put together the „Key“
- one „lock“

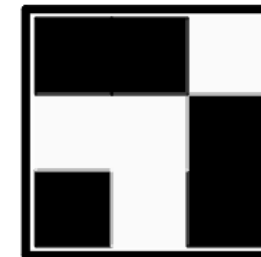
Producing an Escape Game



The final Lock:

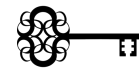
- Analog (e.g. solution word)
- Digital e.g. with Geogebra (file available in Google Docs, can be quickly adapted)
- QR code as solution possible (use of AR "reward")

Note: The digital solution is comparably easy to implement!



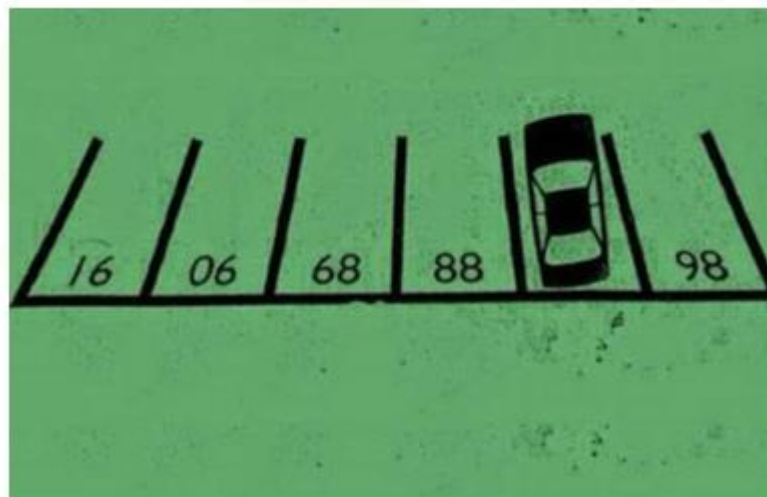
Enter

Example: Participants enter the solution and receive feedback as to whether it is correct or incorrect



Producing an Escape Game:

What characteristics must the tasks fulfill?



What is the number on the parking slot?



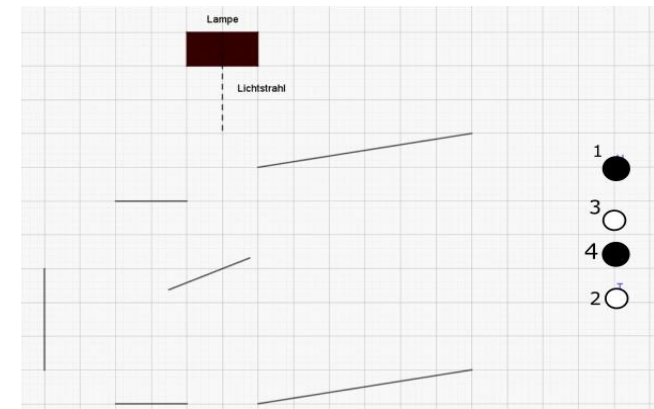
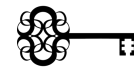
How tall is the person fitting in this chair?

Producing an Escape Game:

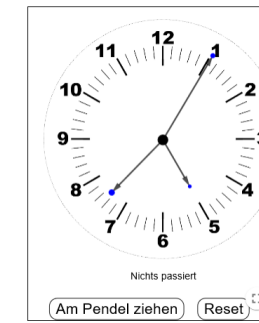
Characteristics of puzzles (the Key):

- Must have a unique solution*
- Easy to implement in analog or digital form
- The solution of the task or puzzle must contribute to the "key"
- Photo of a book task is possible!

Note: This can be weakened to some extent.



Example: Four possible solutions result in different codes



Example: Software gives feedback if right or wrong

Producing an Escape Game

Ideally, the puzzles fulfil the following characteristics:

- Varying (different subject areas, different topics, different type of puzzle)
- Riddels, that foster interest
- Not only math/STEM problems

Hallo,

Habe gerade den tollen EscapeRoom gelöst :D

Codewort: 

Mir gefällt die Varietät an verschiedenen Rätseln, die nicht alle direkt Mathe benötigen. Und, dass man das Sudoku nicht komplett lösen muss, sobald man die Kästchen mit den Farben hat. Zur Kontrolle könnte man das ja machen.

Aber auch, dass man nicht überall direkt rechnen muss.

Nur bei den Spiegeln wusste ich jetzt die Regeln nicht mehr, die wir mal im Physikunterricht in der 10ten Klasse (bin jetzt in der 13) gelernt haben. Die zwei, die ich dachte, die es wären, waren es dann doch nicht. Und beim Detektivrätsel, das ich gelöst hatte, hatte ich die falsche Zahl aufgeschrieben und mich dann gewundert, warum die doppelt ist.

Jetzt hab ich es aber :D

Danke für die Möglichkeit, an sowas teilzunehmen, das hat wirklich sehr viel Spaß gemacht :)

Liebe Grüße,



Now: How to produce escape games?

Aims of the next part:

- How can a digital escape room be structurally implemented as simply as possible?
- How can I implement a puzzle digitally as easily as possible without programming knowledge?
- Outlook: How can it be made more complex?



Escaperoom

Der Raum

Die Netz

Der Spiegel

Der Schreibtisch

Schubladen im Schrank

Der Vorhang

Die Bücher in der Vitrine

Die Vase

Scherben in der Vitrine

Die Uhr

Die dunkle Ecke


Ausgang

Escaperoom

Autoren: ICSE

Mit einem lauten Knall fällt die Tür hinter dir ins Schloss und du weißt sofort: Du bist eingeschlossen! Nachdem du dich kurz orientiert hast stellst du fest, dass sich auf der gegenüberliegenden Seite des Raumes eine weitere Tür befindet. Die ist zwar ebenfalls verschlossen, aber vielleicht löst sie sich durch die Eingabe der richtigen Kombination auf der Schalttafel neben der Tür öffnen? Doch wie kannst du diese Kombination herausfinden? Schaffst du es, dich rechtzeitig zu befreien?

Um aus dem Raum zu entkommen, schau dich genau um! Du wirst verschiedene Rätsel finden, die dir helfen, den richtigen Code an der Schalttafel am Ausgang einzustellen und so die Tür in die Freiheit zu öffnen. Notiere dir die Lösungen der einzelnen Rätsel, damit du sie am Ausgang noch weißt!

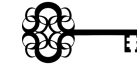


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Der Raum

Der Hauptraum

Building an Escape Game with Geogebra



What is Geogebra:

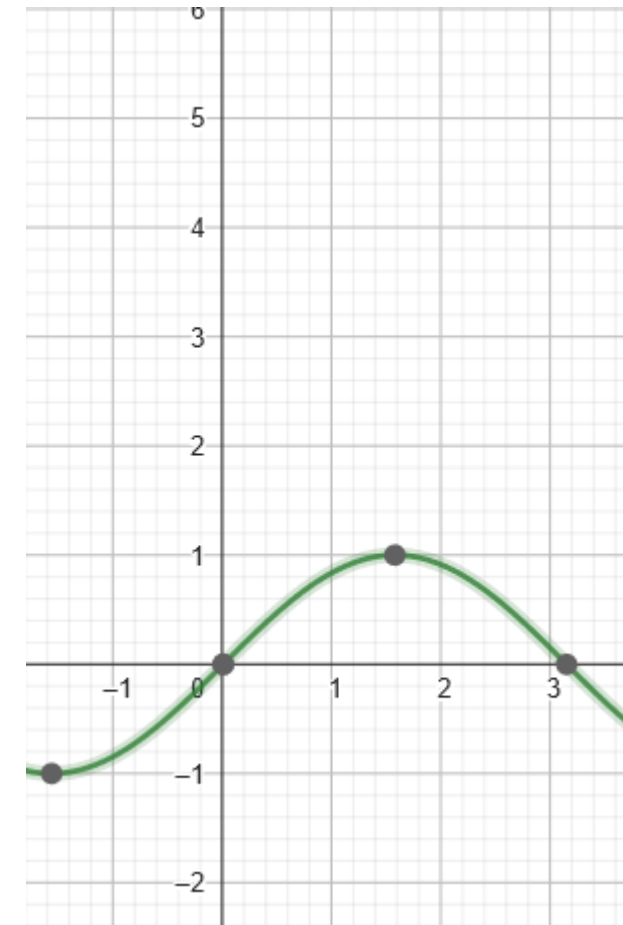
- A web based dynamical geometry software

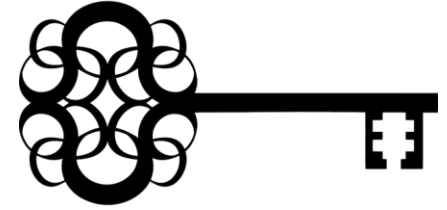
Why using Geogebra?

- Free, easy to use and enough room for complex puzzles
- A lot of STEM applications available that can be adapted for an escape game. (for example: <https://www.geogebra.org/m/g444wWSd>)
- Coding and computational thinking needed to design more advanced puzzles
- Embeddable in webpages

Note: There is plenty of other software to produce

- <https://genial.ly/>
- Google forms
- Powerpoint





Learning by Doing: Produce an Escape Game Puzzle

Principle behind that: You have 4 elements

- Correct Answer
- Answer (to be typed in)
- Information that the Answer is wrong
- Information that the Answer is right

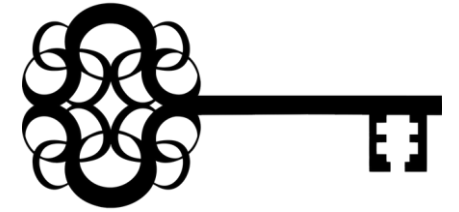
The logic behind that is:

If the “Correct Answer” and the “Answer” are the same, show “correct” and if not, show “wrong”

How many factors does 9 have?

answer

false



Learning by doing: digital implementation of a task

GeoGebra Classic

Replace with task text

The text written in the command line

Right-> insert the information you want

Wrong

Insert your task here

Solution

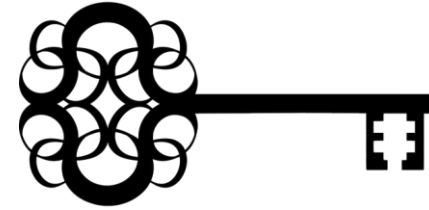
Eingabe...

Insert your task here

Answer The text written in the command lin

Wrong

Replace with the CORRECT solution



Learning by Doing

Excercise: Develop a (simple) digital escape room puzzle.

Use this template or the excercise sheet!

<https://www.geogebra.org/m/dxdy795d>

For the fast ones (use the excercise sheet for that)

1. Try to enhance the Right or Wrong example optically by using graphics
2. Try to understand the coding behind this example

Learning by Doing

Example of a graphically more "opulent" version of ROW

<https://www.geogebra.org/m/ub4sxcjp>

In Geogebra you can easily integrate:

- Graphics
- Sounds
- Some Animations



Now: How to produce escape games?

Implementation option: Geogebra

- Writing a "book" in Geogebra!
- Book=Escape Room
- Chapter=Puzzle



Escaperoom


- Der Raum
- Die Notiz
- Der Spiegel
- Der Schreibtisch
- Schublade im Schrank
- Der Vorhang
- Die Bücher in der Vitrine
- Die Vase
- Scherben in der Vitrine
- Die Uhr
- Die dunkle Ecke
- Ausgang

Escaperoom

Autor: ICSE

Mit einem lauten Knall fällt die Tür hinter dir ins Schloss und du weißt sofort: Du bist eingeschlossen! Nachdem du dich kurz orientiert hast stellst du fest, dass sich auf der gegenüberliegenden Seite des Raumes eine weitere Tür befindet. Die ist zwar ebenfalls verschlossen, aber vielleicht lässt sie sich durch die Eingabe der richtigen Kombination auf der Schalttafel neben der Tür öffnen? Doch wie kannst du diese Kombination herausfinden? Schaffst du es, dich rechtzeitig zu befreien?

Um aus dem Raum zu entkommen, schau dich genau um! Du wirst verschiedene Rätsel finden, die dir helfen, den richtigen Code an der Schalttafel am Ausgang einzustellen und so die Tür in die Freiheit zu öffnen. Notiere dir die Lösungen der einzelnen Rätsel, damit du sie am Ausgang noch weißt!



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- Der Raum
- Der Hauptraum

Now: How to produce escape games?

Aims of this chapter:

- How can a digital escape room be structurally implemented as simply as possible?
- How can I implement a puzzle digitally as easily as possible without programming knowledge?
- Outlook: How can it be even more complex?



Escaperoom

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Now: How to produce escape games?

Implementation option: Geogebra

Geogebra-Book of „our“ Escape Room

<https://www.geogebra.org/m/jfcrbrue#material/htd7znv2>

Why Geogebra?

- Geogebra books can easily be used as a homepage for escape rooms
- Geogebra applets, graphics, PDF files and links can be easily integrated.
- Large number of Geogebra applets enable quick creation of puzzles for escape rooms
- LearningApps can be integrated, for example
- With the classroom function you can check the students' work

Der Hauptraum

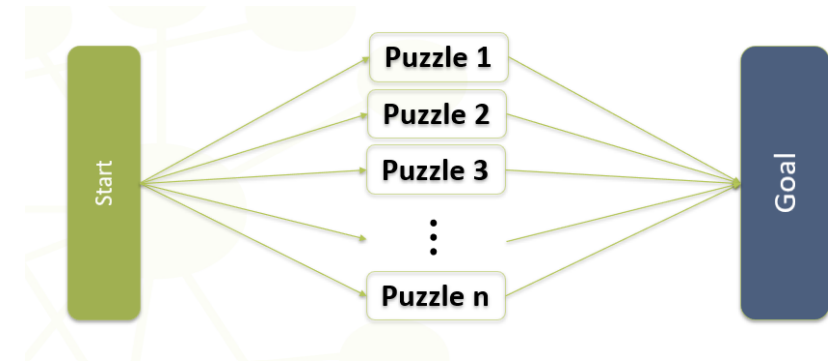


Du gehst aufmerksam durch den Raum und dir fallen verschiedene Dinge auf:

1. Die Notiz
2. Der Schreibtisch
3. Die Uhr

Your Homework...Write a book!

- The "book" is our space (information on how to create a book: <https://www.geogebra.org/m/KBbnFPxH#material/ebS33STT>)
- Each chapter contains a riddle
- The "key" to escape contains as many "digits" as there are chapters (= riddles): in our case 9
- Simplest implementation: Analog or digital
 - (Math) question with answer box → correct answer: part of the key
 - Picture (e.g. of a book task) with answer box → correct answer: part of the key
- More complicated implementation
 - Learning Apps
 - ...feel free to try it out



Short remark: Images

Free pictures (for example “room”)

- <https://pixabay.com/>
- <https://unsplash.com/>

AI Image generator:

- Midjourney
- GPT 4.0
- <https://leonardo.ai/>

“I need a picture for a digital escape room. It should be dark. It should have a locked exit, windows with bars, a laptop, a sofa, a smartphone and a bookshelf.”

Interactive Images

- <https://www.image-map.net/>



Short remark: And if Storytelling is not your thing...

Ask GPT

Prompt:

"Now I have 5 riddles that will be required to open the door. To open the door you need to type in the correct password in the laptop. The other riddles are: a strange contact in the smartphone, a note on the couch, a book with hieroglyphs, a strange smelling flower and a lamp flickering rhythmically. Could you give us a background story to this escape room and especially describe how each riddle is integrated in this story"

Answer:

Story Background:

In the heart of an ancient city lies the forgotten study of the eccentric and brilliant Professor Alaric, a renowned archaeologist and linguist known for his mysterious expeditions. Rumor has it that Professor Alaric discovered a secret so powerful that it could change the course of history. However, before he could reveal his findings, he disappeared without a trace, leaving behind a study filled with enigmas and hidden secrets.

The Setting:

Players find themselves locked in Professor Alaric's study, a room filled with antiques, old books, and strange artifacts. The only way out is through a locked door, which can be opened by solving riddles linked to the professor's research and discoveries.



Short remark: And if Storytelling is not your thing

1. The Laptop Password:

1. **Story Integration:** The laptop contains Professor Alaric's research notes and possibly the key to his disappearance. To access it, players must decipher the correct password.
2. **Riddle Element:** Players must solve the other riddles in the room, which will each provide a letter or number. Once all elements are gathered, they must rearrange them to form the password.

2. The Strange Contact in the Smartphone:

1. **Story Integration:** The smartphone belonged to Professor Alaric's assistant, who was in communication with a mysterious contact. The contact's name is a clue to one of the password elements.
2. **Riddle Element:** Players must navigate the phone to find a contact with an unusual name that, when decoded, reveals a part of the laptop's password.

3. The Note on the Couch:

1. **Story Integration:** An old note left carelessly on the couch, perhaps by the professor himself, contains cryptic references to his research.
2. **Riddle Element:** The note has a hidden message that can be seen under a specific light or angle, revealing another piece of the password puzzle.

4. The Book with Hieroglyphs:

1. **Story Integration:** Among the professor's collection is an ancient book filled with hieroglyphs, a subject of his expertise.
2. **Riddle Element:** Players must translate a specific hieroglyphic passage, which gives them another part of the password.

5. The Strange Smelling Flower:

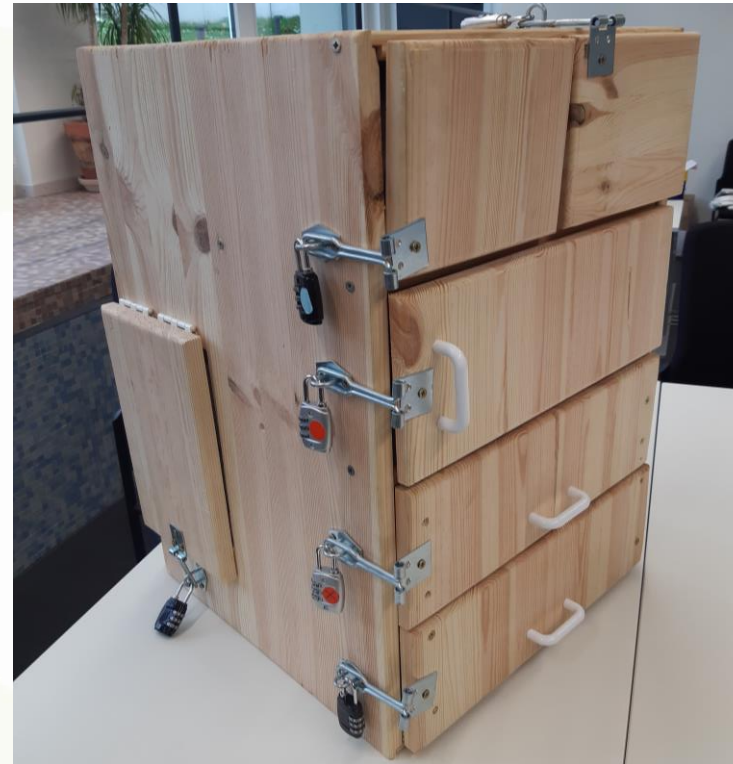
1. **Story Integration:** A rare and exotic flower sits in a vase, its origin unknown, but its aroma triggers memories or thoughts.
2. **Riddle Element:** The smell of the flower is peculiar and corresponds to a specific chemical formula that the professor worked on, hidden in his notes, leading to another password component.

6. The Rhythmically Flickering Lamp:

1. **Story Integration:** An old lamp flickers in a rhythmic pattern, not due to faulty wiring, but by design.
2. **Riddle Element:** The flickering pattern represents Morse code, which, when deciphered, reveals the final piece of the password.

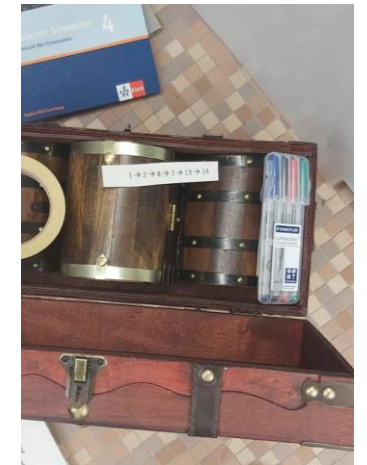
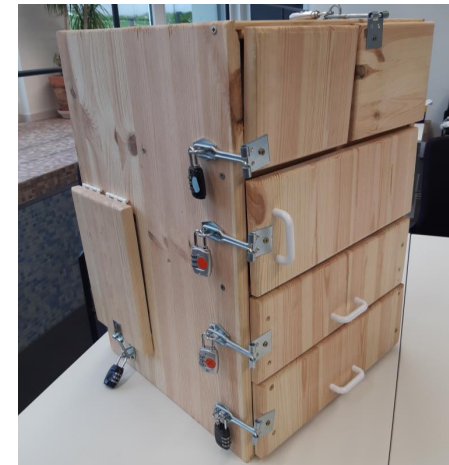


Outlook: Escape Games as a student project



A short history on this digital „Escape Room“

1. This escape room was an emergency product
2. Due to the coronavirus crisis in 2020, the local education fair "Science Days" was canceled and implemented digitally.
3. We were therefore unable to use the physical escape room that we actually wanted to use.
4. Now we will talk about STEM and digital competencies that are needed to build an Escape Room



Whats now behind this example?

Scripting in Geogebra

Our answer check worked as follows:

If **input=solution**, then show the text "**correct**", otherwise show the text "**incorrect**".

Principle:

If x happens, then do y, otherwise do z
 If x happens, then do y,
 otherwise do z

The screenshot shows the Geogebra interface. At the top is a toolbar with various icons. Below it is a script editor with a list of actions:

⊞	Solution	⋮
⊞	Right-> insert the information you want	⋮
⊞	Wrong	⋮
⊞	Insert your task here	⋮
⊞	Solution	⋮
+	Eingabe...	

Below the script editor is a task view. It contains the text "Insert your task here" and a text input field with the value "Solution". Below the input field, the text "Right-> insert the information you want" is displayed in green.

What is behind the right or wrong example?

Right click on the wrong or right text and then choose settings

Conditional visibility

The "conditional visibility" function enables a very simple conversion of Geogebra applets into "Escaperoom-compatible" tasks.

Example:

The green text is only displayed if the entered text corresponds to the text of the solution!

Basic Text Color Position
 Advanced Algebra Scripting
 Condition to Show Object
 Eingabe = Loesung
 Dynamic Colors
 Red:
 Green:
 Blue:
 RGB ▾ REMOVE
 Diverses

What is behind the right or wrong example?

Coding (Scripting)

- You can do the same with coding
- Geogebra has its own very simple programming language (**links in the addendum**)
- Or you can use Javascript
- You then have operators like "=", "<", ">" as well as "and", "or" giving you more flexibility

Basic Text Color Position
 Advanced Algebra Scripting

Condition to Show Object
 Eingabe = Loesung

Dynamic Colors

Red:

Green:

Blue:

RGB ▾ REMOVE

Diverses

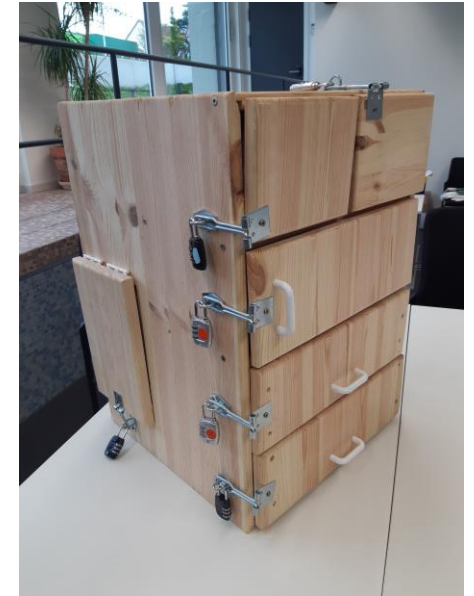
Summary: STE(A)M & Digital Competencies needed for

Digital Literacy and Technology

1. Web design & coding
2. Image Editing
3. Game design.

STE(A)M

1. Storytelling
2. Science knowledge
3. Technology Integration



Example: Student project about escape games

1. 5-Day workshop with the goal to produce a 3D-printed “hybrid” escape game (including digital puzzles <-> QR-code, and physical tasks)
2. Students in age from 12 to 18
3. Offered workshops in this week
 1. CAD and 3D-Printing
 2. Escape Design
 3. Storytelling
 4. Image Editing
 5. Coding with Geogebra and Javascript



This 5-day workshop was accompanied by a study

1. Positive change in self-efficacy
2. Positive change in attitudes towards STEM
3. Participants were extremely proud of their products



Part IV: Addendum



Outlook

Geogebra's own programming language

<https://wiki.geogebra.org/en/Scripting>

Java

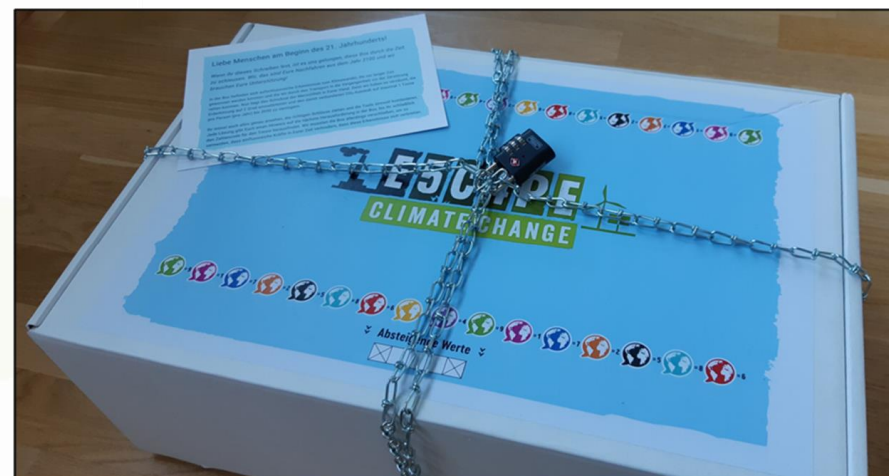
<https://wiki.geogebra.org/en/Scripting>

Research Results on Educational Escape Games

- Escape games can improve students' motivation and attitudes towards STEM subjects.
- Escape activities can increase students' skills in cooperation, communication as well as problem solving.
- Well-designed escape games have the potential to particularly attract girls and low-performing students.
- When the Escape activities are linked to the students' existing knowledge in a classroom debrief, this can increase cognitive knowledge.

Example: Escape Climate Change

- Physical box
- Can be borrowed by schools
- played as a class
- Story: letter from the future, have to save the world
- Riddles about greenhouse gases, emissions by sectors and countries, consequences, solutions



Example: Escape Room on Sustainable Development

- Physical Room made from recycled materials
- For teenagers and adults in teams of four
- Topic: Responsible consumption and production
- Story: Make decisions and achieve as many goals as possible before the year 2030
- Build by students of the Rotterdam School of Management in cooperation with an escape room professional



Example: On the trail of the greenhouse effect

- Rallye through exhibition about climate change
- With app Actionbound
- Alone/small groups
- Main target group: teenagers
- Story: The ghost of Eunice Foote wants to know about what happened since she died.
- Riddles about climate science, that can be answered by exploring the exhibition



Example: Ocean Eye

- Big box placed in museums and similar
- For teenagers and adults
- 3-6 people
- Story: Help a scientist who is supposed to go to jail for a murder she did not commit!
- Riddles: Experiments on (micro) plastics
- Made by science centre network and escape room professionals



