Mathematics outdoor with

MathCityMap

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What is the talk about?

- **Theoretical foundations on outdoor mathematical modeling**

- Presentation of the MathCityMap system

- Methodology for conducting math trails with students

- Creating your own tasks: design criteria and response formats

Potential for outdoor learning

- Great potential is ascribed to learning outside of the classroom (DfES, 2006)
  - Creativity
  - Developing subject-related and interdisciplinary skills
  - Attitude towards learning
  - Motivation
- Long-lasting memories of learning outside (Dillon et al., 2006)

# Potential for outdoor learning of mathematics
(Sauerborn & Brühne, 2009)

Potentials	Challenges
• Primary experiences • Learning by active construction • Immediate application of theoretical concepts • Increased interest • Interdisciplinary Learning	• Additional logistical, legal, and organisational effort • Curriculum and assessment • Abuse of freedom

Mathematical modelling

- Mathematical modelling is mostly done within the classroom
- The required data is usually provided in image or text form

Container task

The container is supposed to be filled up to the top.
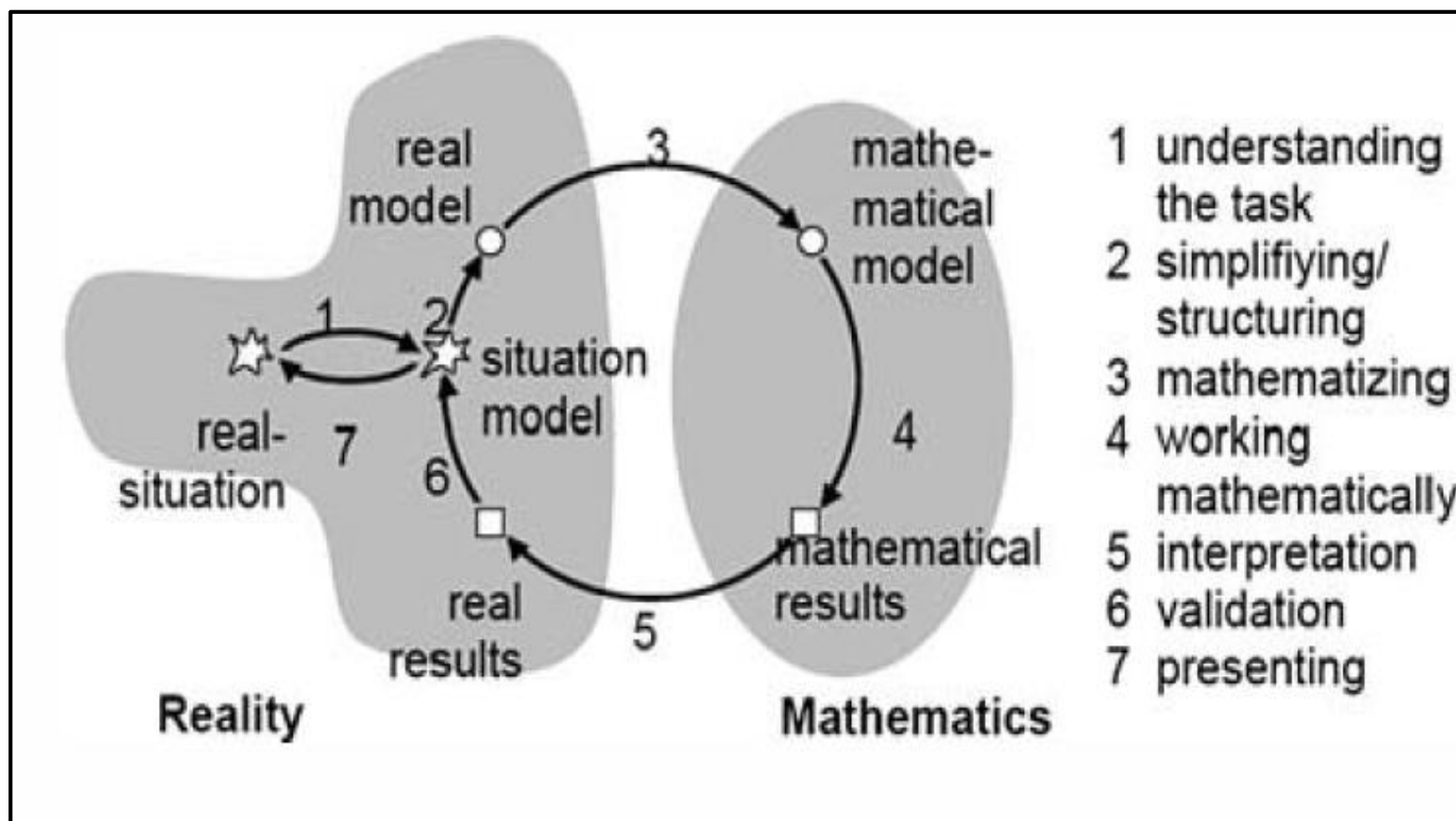How much sands fits inside the container?
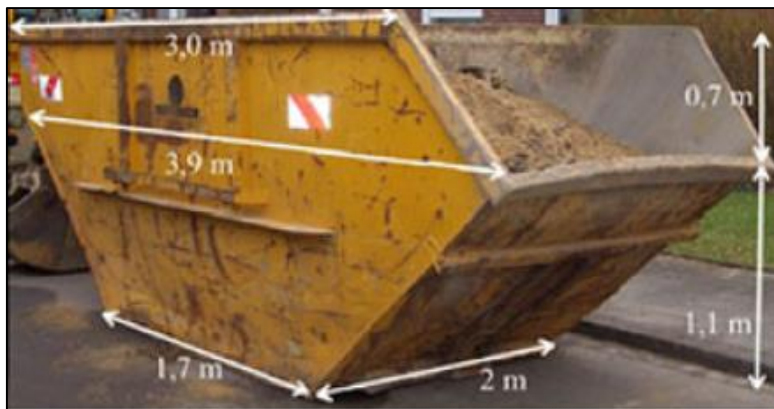
Tasks & Picture from:
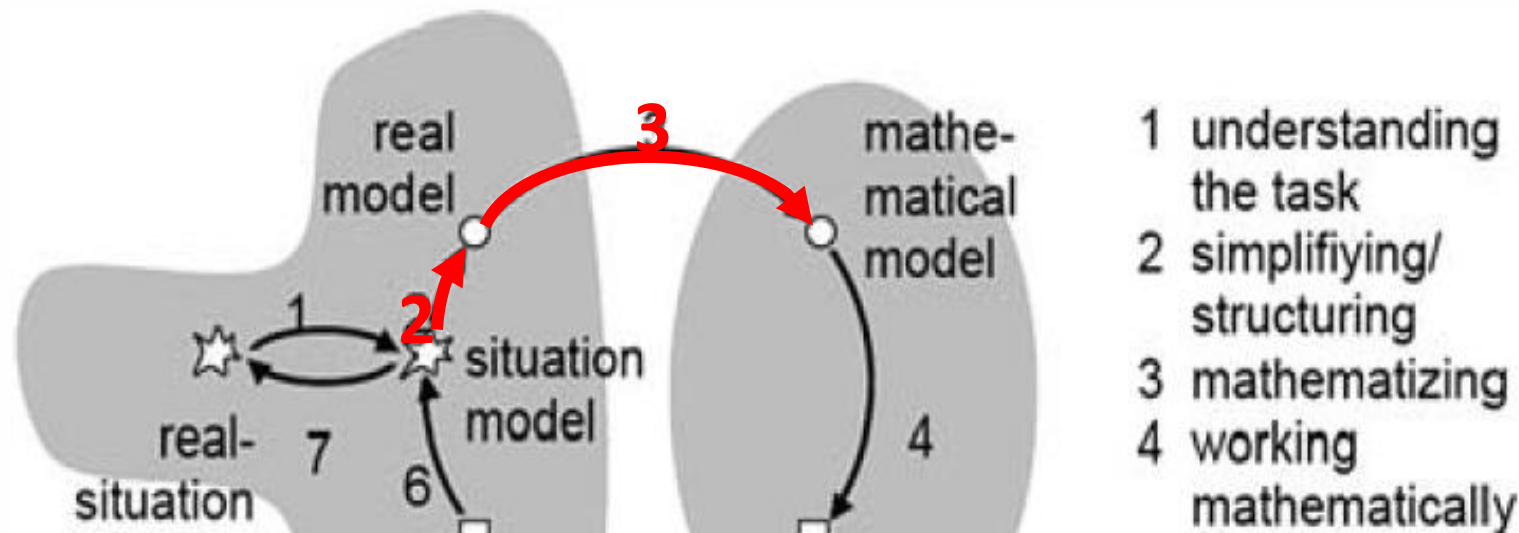Greefrath (2018)

Working on this task outdoors

Modelling cycle according to Blum and Leiß, 2005

Modelling challenges (Schukajlow, 2006)

- Finding an adequate real model and a mathematical model for the given situation (steps 2 & 3)

- Deciding which data must be collected:
  mathematization of the situation, definition of variables

Mathematical Modelling
Variety of possible models

Determine the weight of this stone at Camps Bay Beach, South Africa (in kg)
1 cm³ weighs approx. 2.6g.

Possible mathematical models:

- Sphere
- Cylinder
- Cuboid
- Prism
- Ellipsoid

Mathematical Modelling
Variety of possible models

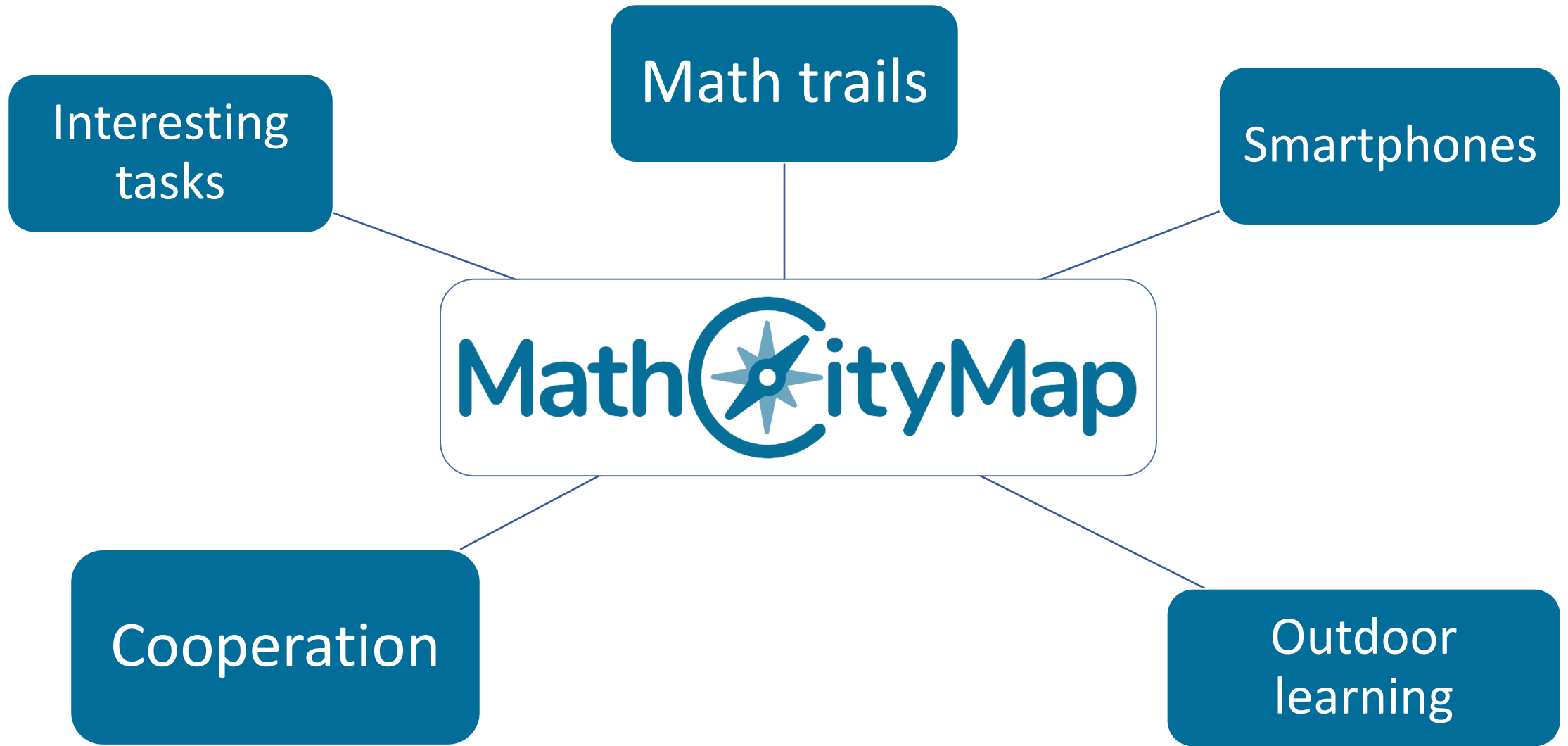| Mathematical model	Mathematical calculations (with measuring deviations of 2cm)	Result
Cuboid length: 112cm width: 78cm height: 58 cm	$(112m \pm 2cm) \cdot (78cm \pm 2cm) \cdot (58cm \pm 2cm)$ $= 507680cm^3 \pm 39500cm^3$	$1320kg \pm 103kg$
Cylinder	$536018cm^3 \pm 37008cm^3$	$1393kg \pm 96kg$
Ellipsoid	$199215cm^3 \pm 15369cm^3$	$518kg \pm 40kg$ Bad model!

Math trails

- A math trail is a mathematical walking trail
  - A walk through which mathematics can be experienced (Shoaf, Pollak & Schneider, 2004)
  - Discovering mathematics in intersting places and at interesting objects
- Can take place anywhere and is suitable for all age groups (Ludwig, Jesberg & Weiß, 2013)
- First math trail already over 30 years ago on Australia: A Mathematics Trail Around the City of Melbourne (Blane & Clarke, 1984)
- Helpful: A guide (real person or paper guide)
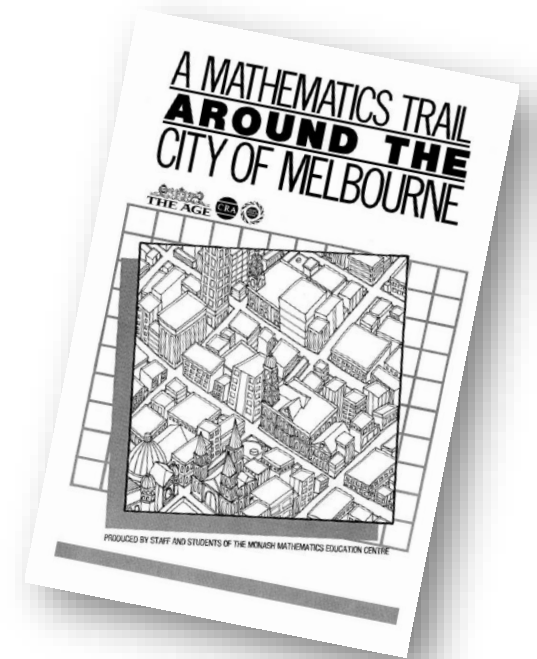
# Math trails

Methodological characteristics:

- Form of outdoor learning

- Working in small groups

- Realistic and authentic problems

- Interdisciplinary learning

- Importance of mathematics in everyday situations

Math trails

Interesting tasks

Smartphones

MathCityMap

Cooperation

Outdoor learning

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The MathCityMap system
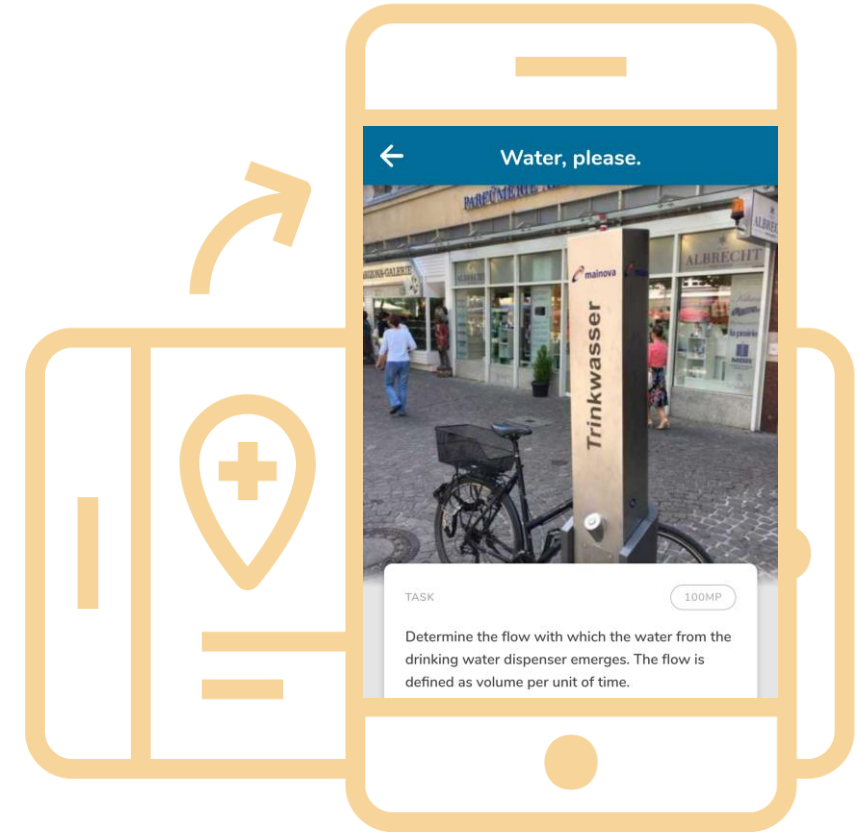
MathCityMap idea: Web portal

- The tasks are marked on a map!

Web portal: Home page

Web portal: Map view

MathCityMap-Idea: Webportal

- The tasks are marked on a map
- **Tasks can be accessed in the portal**

Web portal: Calling up tasks

Web portal: Calling up tasks

MathCityMap idea: Web portal

- The tasks are marked on a map
- Tasks can be accessed or created in the portal
- **Several tasks form a Math trail**

Web portal: Home page

MathCityMap idea: Web portal

- The tasks are marked on a map

- Tasks can be accessed or created in the portal

- Several tasks form a math trail

- **The tasks are set in such a way that they can only be solved on site
  e.g. measurements must be collected**

MathCityMap idea: Web portal

- The tasks are marked on a map

- Tasks can be accessed or created in the portal

- Several tasks form a math trail

- The tasks are set in such a way that they can only be solved on site e.g. measurements must be collected

- **Everyone can participate and create their own tasks and math trails**

Create your own tasks & math trails
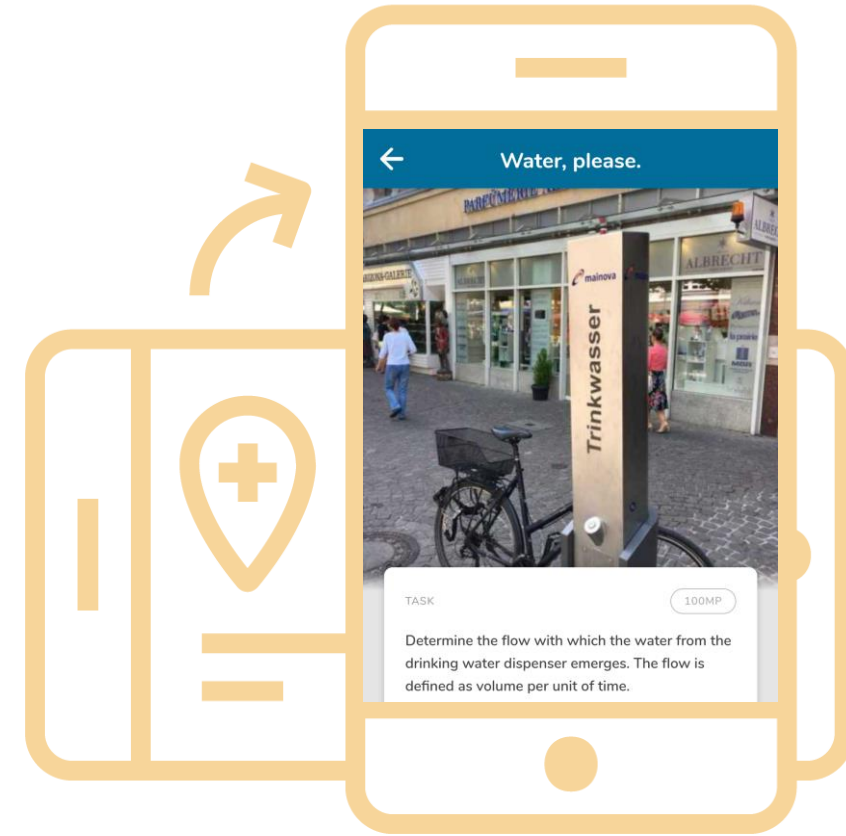
The MathCityMap system

MathCityMap idea: App

- Trails are downloaded to the smartphone

- The MathCityMap app is free of charge and advertisements and it respects personal data protection (GDPR)

- The app is available for Android & iOS
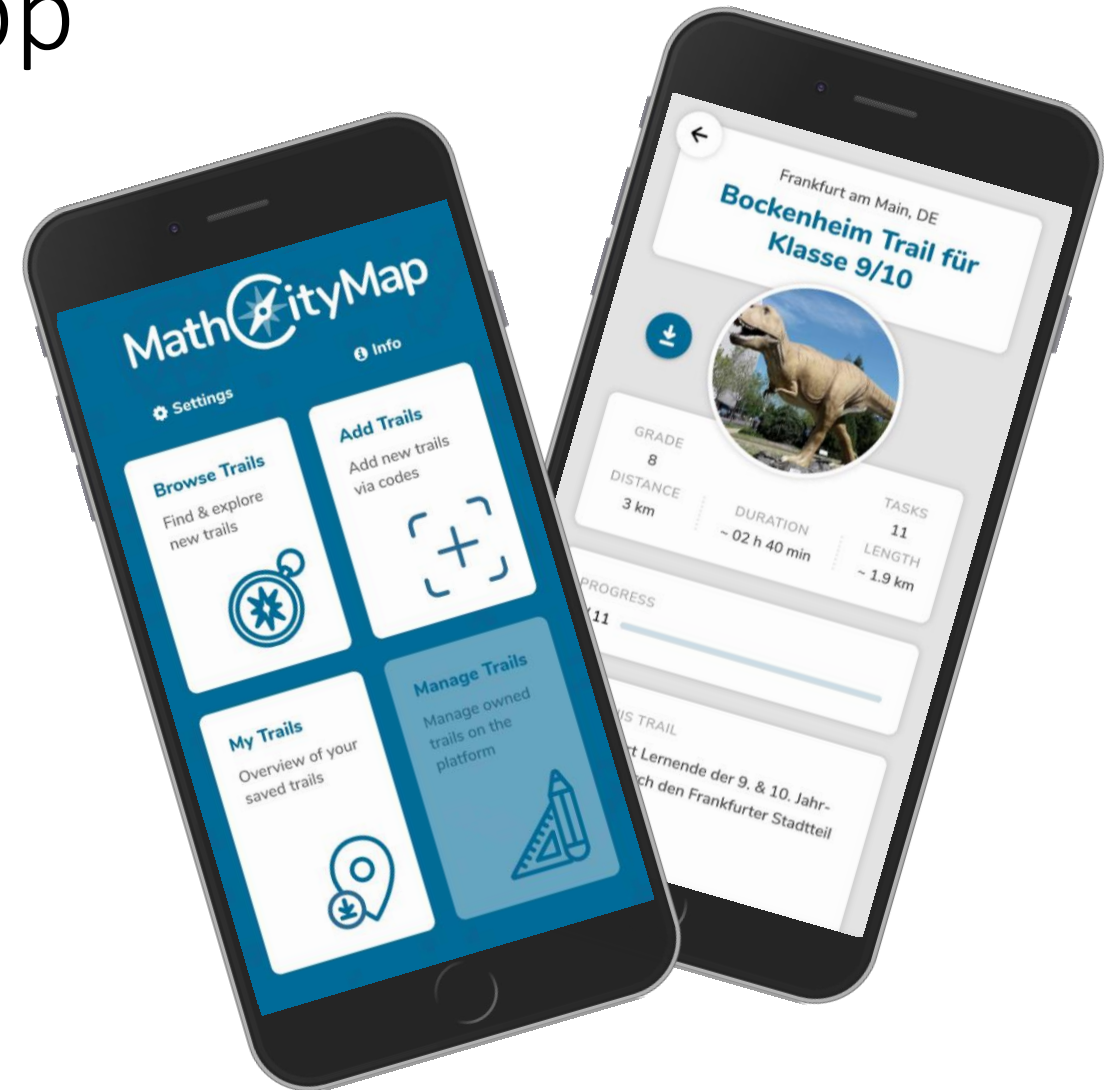
Paper guide and/or smartphone app
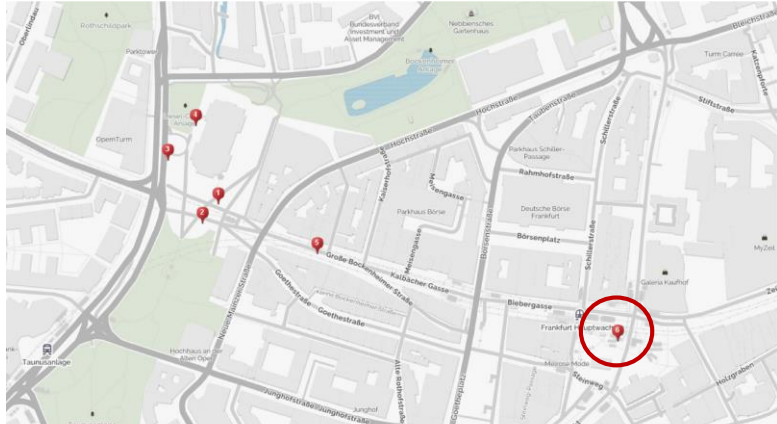
The tasks are called up via the smartphone and/or a paper guide is used

MathCityMap idea: App

- Trails are downloaded to the smartphone
- The tasks are called up via the smartphone and/or a paper giude is used
- **Help or hints can be called up via the app**

MathCityMap idea: App

- Trails are downloaded to the smartphone

- The tasks are called up via the smartphone and/or a paper giude is used

- Help or hints can be called up via the app

- **The solution is checked by the app**
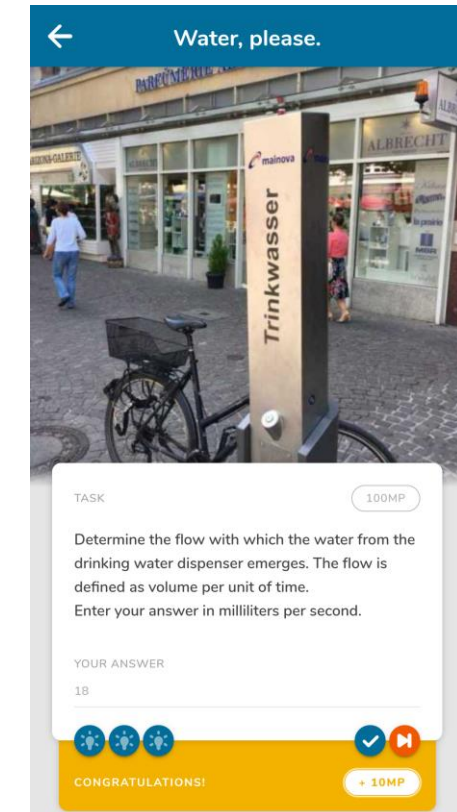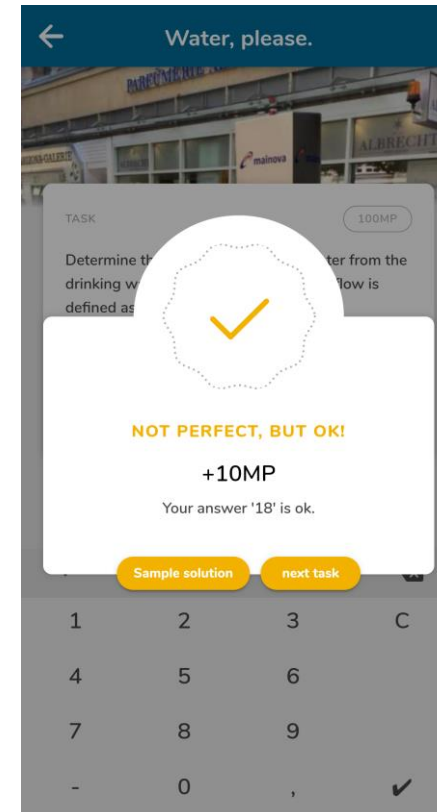
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MathCityMap in class
Preparation in the classroom

- Form groups of 3 members each

- Take one math trail set per group:
  folding rule, measuring tape, trail guide, pen

- Each group needs only 1 active smartphone with the MCM app

- There are 3 roles – changing the rolls is desired:
  - Navigator   operates the app, helps to find tasks
  - Measurement expert   responsible for exact measurements and tools
  - Secretary   records measured values and solution path

MathCityMap in class
Conduction of outdoor learning

Circle of stations: app guides groups to the next task
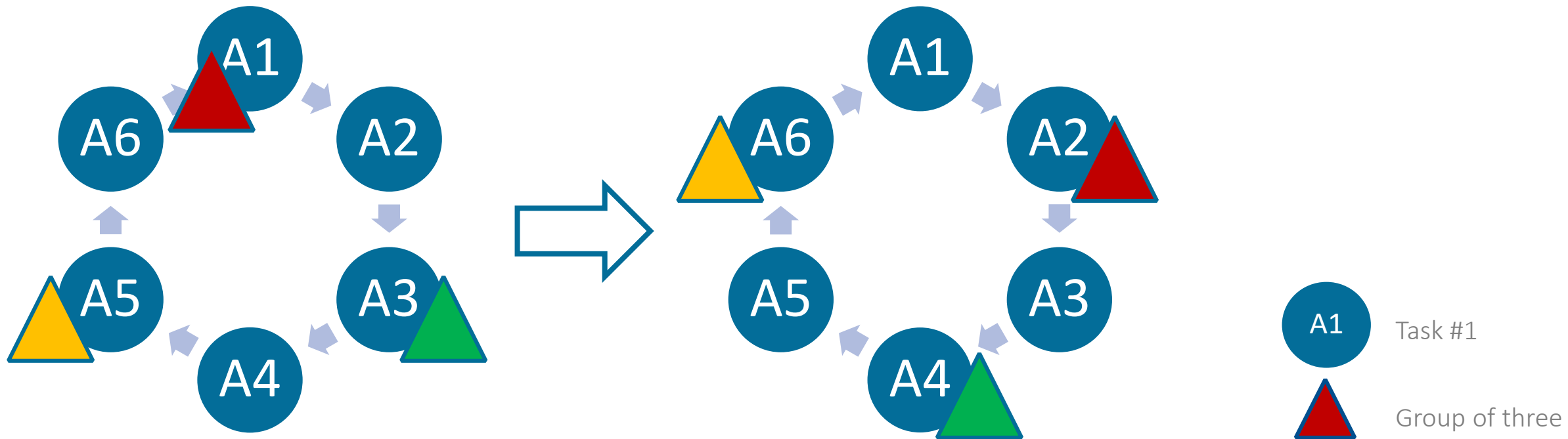
MathCityMap in class
Digital classroom

- Digital real-time representation of a class along a trail

- Three functions:
  - **Organisational function: Location & progress of each group**
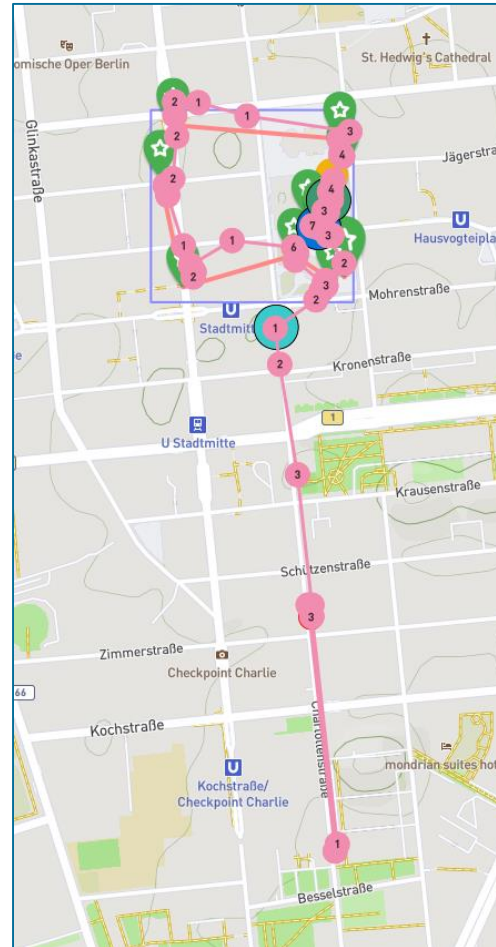
MathCityMap in class
Digital classroom

- Digital real-time representation of a class along a trail

- Three functions:
  - Organisational function
  - **Communication function: Chat between teacher & pupil groups**
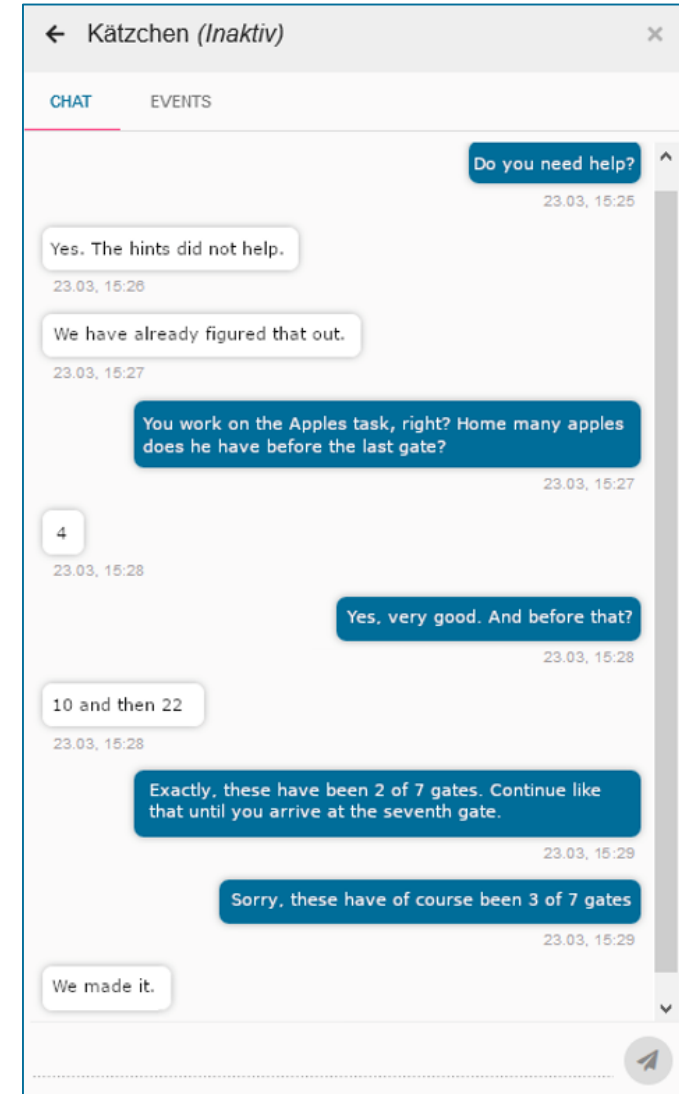
MathCityMap in class
Digital classroom

- Digital real-time representation of a class along a trail

- Three functions:
  - Organisational function
  - Communication function
  - **Evaluation function: Detection of potential errors through event view**
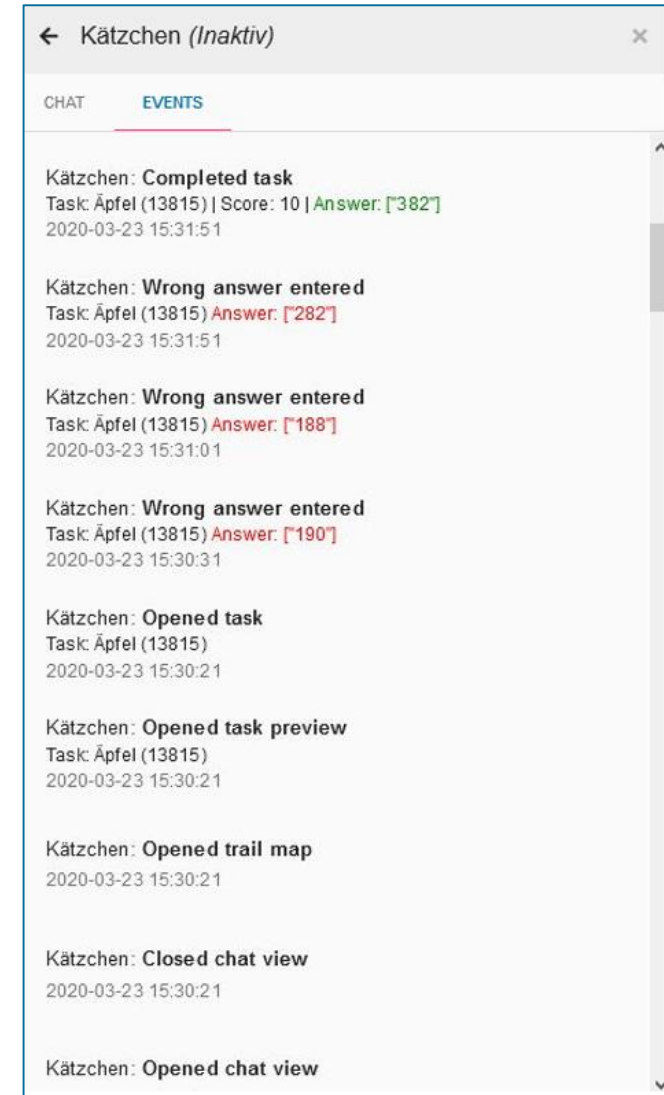
MathCityMap in class
Digital classroom – data protection

- The data is processed and stored in Germany (1&1 – Frankfurt).
- The collected data is <u>not</u> personalized
  - No registration for students necessary
  - Identification through radom temporary keys (no clear names or e-mails necessary)
  - Encrypted data transmission (SSL)
- **MathCityMap complies with the provisions of the GDPR**

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Own tasks & Math trails

- MathCityMap is a participatory project:
  Anyone can create a math trail in their own city

- Web portal: https://mathcitymap.eu

Own tasks & Math trails
Web portal

Create your own tasks & Math trails

Own tasks & Math trails

- MathCityMap is a participatory project:
  Anyone can create a math trail in their own city

- Web portal: https://mathcitymap.eu

- **Registration is required to create tasks**

- **To create a math trail, several tasks are combined into one such trail**

Own tasks & Math trails

- Own content (tasks & trails) are private by default
- They can be shared by **code** or in a **working group**

- Publication of own contents possible on request
  - Tasks go through a review process
  - Tasks are checked for the following **quality citeria**

Criteria for a MCM task I

- **Clarity:**
  For each task, a **picture** must be created that allows the clear identification of the situation or the object the task is about.

- **Presence:**
  The task can only be solved **on site**, i.e. the task data must be collected on site. This also means that the picture or the task description must not be sufficient to successfully solve the task.

- **Activity:**
  The person who solves the task must be **active** and do something (e.g. measuring or counting).

Criteria for a MCM task II

- **Multiple solutions:**
  The task should be solvable in **different ways**.

- **Reality:**
  The task should be **application-oriented**, realistic and not too contrived.

- **Graduated hints:**
  At least two **hints** should be added to each task.

- **School mathematics and „tags":**
  The task should have a clear relation to school mathematics: Use the prepared tags or add new **terms**. The task should also be assigned to a **class level.**

Criteria for a MCM task III

- **Solution formats:**
  The solution of the task should be expressed through one of the **response formats** that the sistem provides.

- **Tools:**
  No special tools should be required to solve the task.

- **Sample solution:**
  One should offer a **detailed solution and hints** (only visable in the portal) for teachers.

Respone formats

- Exact solutions

- Multiple choice

- Intervals

Structure of the solution interval:
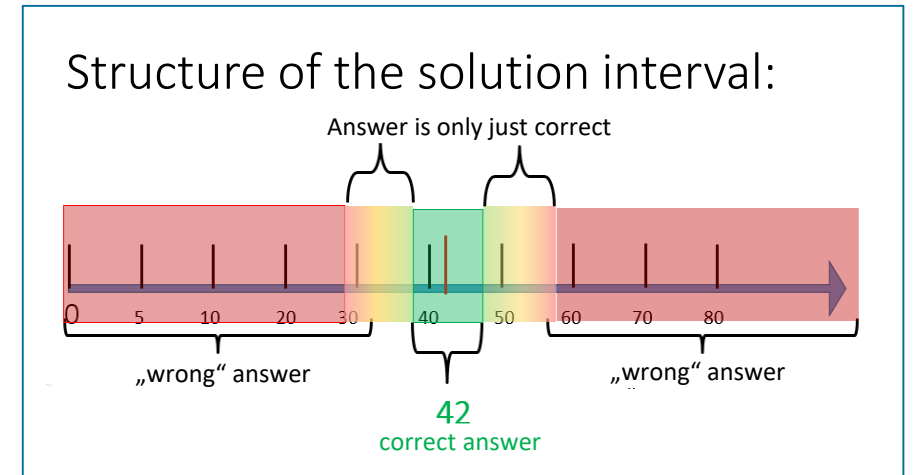
Which response format fits best to my task idea?

Response formats: Exact solution

- Usage scenarios:
  - Combinatorial questions with an exact answer
  - Counting tasks where the number can be determined very accurately
- Example:
  - How many windows are visible on the south side of the building?
    Answer: 40

- **Author** defines in the web portal: Number
- **User** enters in app: Number

Response formats: Interval

- Most common task type
- BUT: Badly calculated intervals can cause frustration!

- Usage scenarios:
  - All tasks that require measuring in the process.
- Example:
  - Determine the area of the (rectangular) schoolyard in m².
    Solution: A = a · b = 100m · 50m = 5000 m²
  - BUT: Other measured values are conceivable (e.g. a = 99,5 m; b = 49,8 m)

The interval should contain all results that arise from acceptable deviations in the measurement!

Response formats
Interval: calculate interval limits

The „measured value" method:

- A deviation is defined for each measured value which is still accepted (e.g. 3%-deviation for green & 7%-deviation for orange interval):

Acceptable measurement error	Own measurement	Acceptable measurement error
a_1 = 97m	a = 100m	a_2 = 103m
b_1 = 48,5m	b = 50m	b_2 = 51,5m
A = $a_2 \cdot b_2$ = 4704,5m²	A = a·b = 5000m²	A = $a_2 \cdot b_2$ = 5304,5m²

- Same procedure for the orange interval
- This leads to the following interval limits:

4325	4704	5305	5725

Response formats: Interval

- Usage scenarios:
  - All tasks that require measuring in the process

- Example:
  - Determine the area of the (rectangular) schoolyard in m².
    Solution: $A = a \cdot b = 100m \cdot 50m = 5000$ m²

4325	4704	5305	5725

- **Author** defines in the web portal: 4 numbers (limits for green & orange interval)

- **User** enters in app: Number

Response formats: Multiple choice

- Usage scenarios:
  - Tasks that have several correct answers
  - Tasks that have terms as answers (equations, technical terms)
  - Tasks that present equivalent answers (e.g. 3·2, 6)
- Example:
  - What geometric shapes and bodies can you recognize in the Leaning Tower of Pisa?
    - a) squares
    - b) triangles
    - c) cylinders
    - d) circles

- **Author** defines in the web portal: 4 answers of which 1-4 may be correct
- **User** enters in app: Checks all correct answers

Response format: some news

https://mathcitymap.eu/it/the-mathcitymap-task-formats/

- Vector (interval)
- Vector (exact value)
- Set
- Fraction
- Information station
- Fill in the blanks
- Support tasks

For more information

Contact in Italy:
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www.mathcitymap.eu   www.masce.eu

Literature

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Same math trails as example

MathCityMap

MathCityMap - Liceo Matematico - Sample solution

Code: 1413844

Emanuele Amico, Salvatore Andrea Frazzetta, Simona Costa, Luana Nicosia, Claudia Alfano, Francesco Pulvirenti, Antonino Casto, , Veronica Sambataro, Eugenia Taranto, Maria Flavia Mammana

MathCityMap

Matematica in giro ad UniSa - Sample solution

Code: 6813326

Eugenia Taranto

MathCityMap

Matematica in centro - Torino - Sample solution

Code: 1810212

Eugenia Taranto, Giulia Ferrari

Now is your turn!

Divide into groups to create 8 tasks (this is the minimum number to generate a trail)

With your group, find 2 interesting objects outside (up to 17:00).

Create your tasks in the MCM system (up to 17:30) and share it in the "**Trieste**" group (code **254009**).