

WaterLab – A VR learning environment about water resource management

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Motivation

WATER SCARCITY - A GROWING CHALLENGE

- 2.5 billion suffering from water scarcity [1]
- Demand increasing due to climate change and a growing population

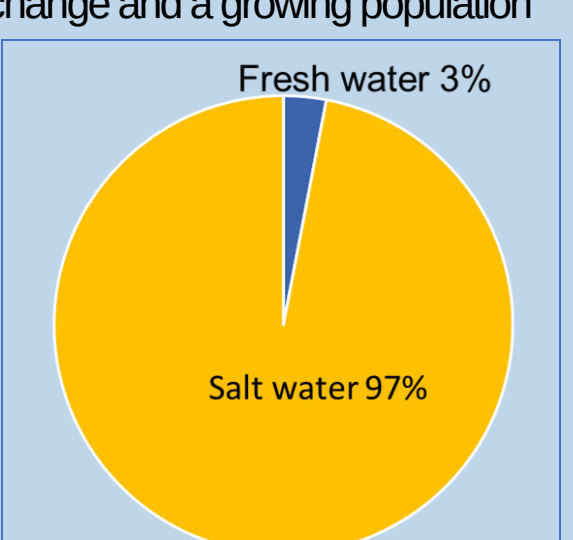


Figure 1. Total Earth's water population. Source: "Desalination". Lecture by Prof. Dr. Nacken and F. Balmes, Institute of Hydrology, MSc Study Program Sustainable management – Water and Energy, RWTH Aachen, November 2024.

SEAWATER DESALINATION

- Addressing global water scarcity BUT: energy-intensive!

Major focus in the education of future hydrologists!

WATER-FOOD-ENERGY NEXUS

- Need to re-think established ways of water resources management & introduce more sustainable ways of fresh water production.

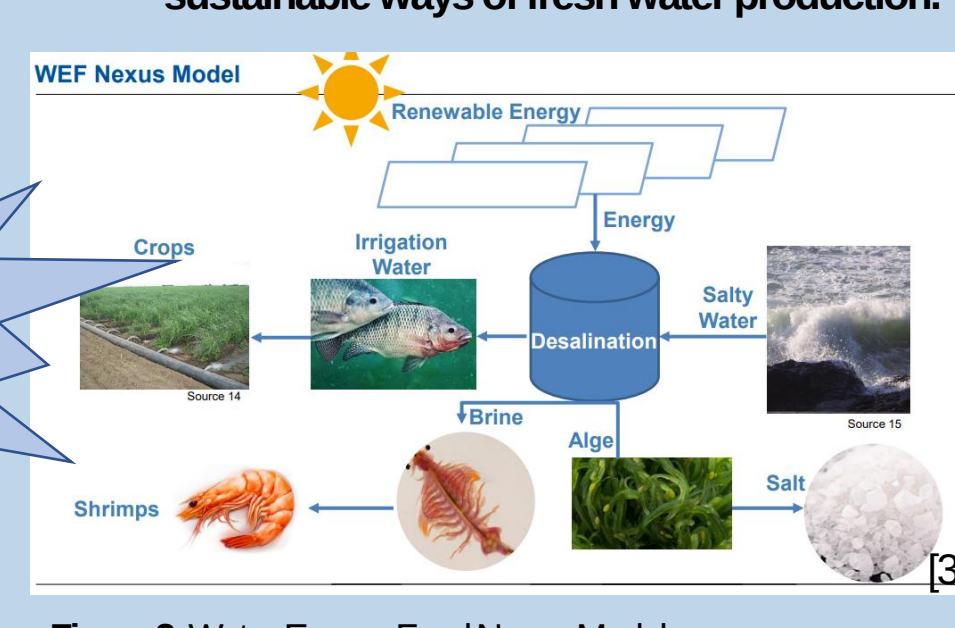


Figure 2. Water-Energy-Food Nexus Model. Source: "Water-Food-Energy Nexus". Lecture by Dr.-Ing. H. Sewilam, Institute of Hydrology, RWTH Aachen, MSc Study Program Sustainable management – Water and Energy, Moodle resources, 2024.

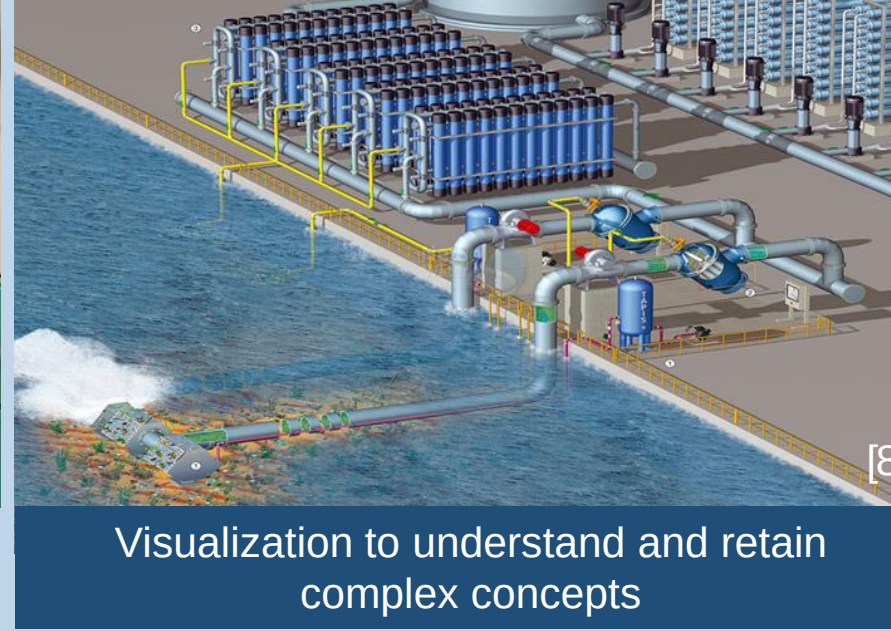
Usecase

EDUCATIONAL CONTEXT

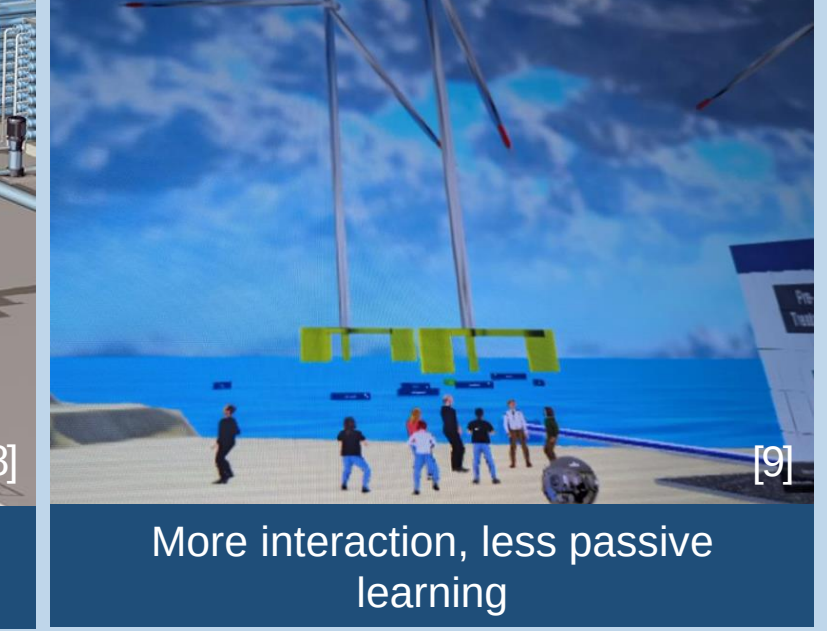
- To enhance Master's level study programs in Hydrology/ Environmental Engineering.



Active, experiential learning to complement theory



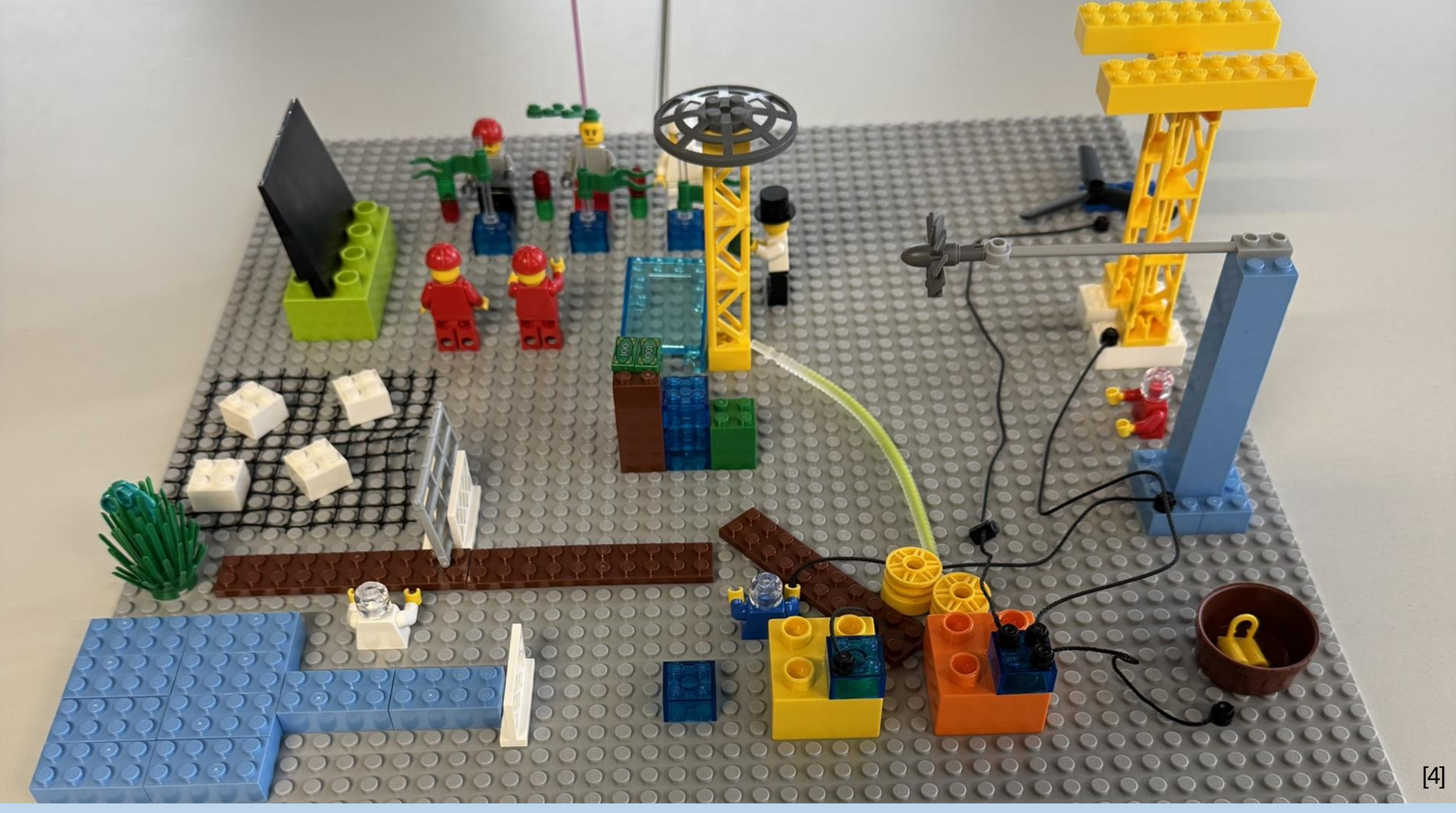
Visualization to understand and retain complex concepts



More interaction, less passive learning

Tool

ROLE-PLAYING VR SIMULATION GAME DEDICATED TO THE DECISION-MAKING PROCESS OF PLANNING A DESALINATION PLANT



PLAN A DESALINATION PLANT

BALANCE STAKEHOLDER REQUIREMENTS



...WITH BOUNDARY CONDITIONS



...BY SELECTING A DESALINATION METHOD



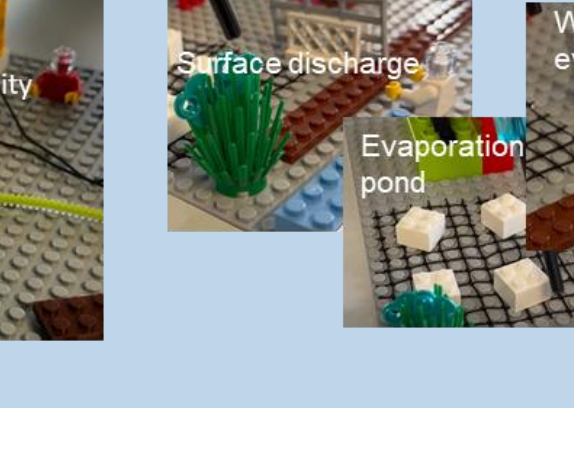
...BY DECIDING ON THE NEED FOR PRE-AND POST-TREATMENT



...BY SELECTING AN ENERGY TYPE (balancing sustainability and efficiency)



...AND ON BRINE DISPOSAL METHOD (footprint vs. cost)



VISUALIZE OVERALL DECISION OUTCOMES



Visualize....

- CAPEX
- OPEX
- Energy consumption
- CO2 emissions

[4]

Research findings

END-USER NEEDS ALIGN WITH VR AFFORDANCES

Based on interviews with students (n = 17) ...

... Need more visual learning

"Theoretical lectures alone are not helpful! ... **Visualization** is so important for us engineers. Equations are not just data – I need to visualize information to make sense of it!"

... Hands-on learning

"To understand, I need to apply what I learned. Otherwise, I don't learn deeply."

... Interactive learning

"There is not much discussion during lectures, I don't feel involved."

Based on students' first VR experiences (n = 8) ...

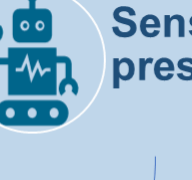
Anticipating high potential to enhance learning



Active exploration



Collaboration



Sense of presence

- Learner engagement
- Memorability
- Enhanced learner experience

Tool currently in software development stage

Usability

HUMAN-CENTERED APPROACH to ensure usability...

NEEDS
Identified user needs the tool will cater to



USER INVOLVEMENT
Involved end-users in the entire design

Conclusion & Future Work

ANTICIPATED IMPACT

RISK-FREE EXPERIMENTATION & VISUALIZATION OF COMPLEX ENGINEERING SOLUTIONS

- Learners **tackle complex engineering projects** and take appropriate measures to **improve sustainability**.
- Designed to **simulate real world situations**, leveraging engineering knowledge and project management skills.

COMPLEMENT FRONTAL TEACHING

- Visual and hands-on** learning opportunity to complement university lectures
- Increased **engagement** and enhanced **learner experience**

BEYOND ENGINEERING KNOWLEDGE

- Supporting **skills development beyond technical skills and engineering knowledge** (managing stakeholder requirements, considering specific conditions, e.g., water demand and cost)
- Those soft skills are **rarely taught to engineers**.

OUTLOOK

EVALUATION AND FURTHER ITERATIVE DEVELOPMENT

An **evaluation and iterative development of the learning scenario** is intended, after the first cycle of software development has been completed.

In a subsequent step, we plan the development of **learning modules** in a co-creation process.

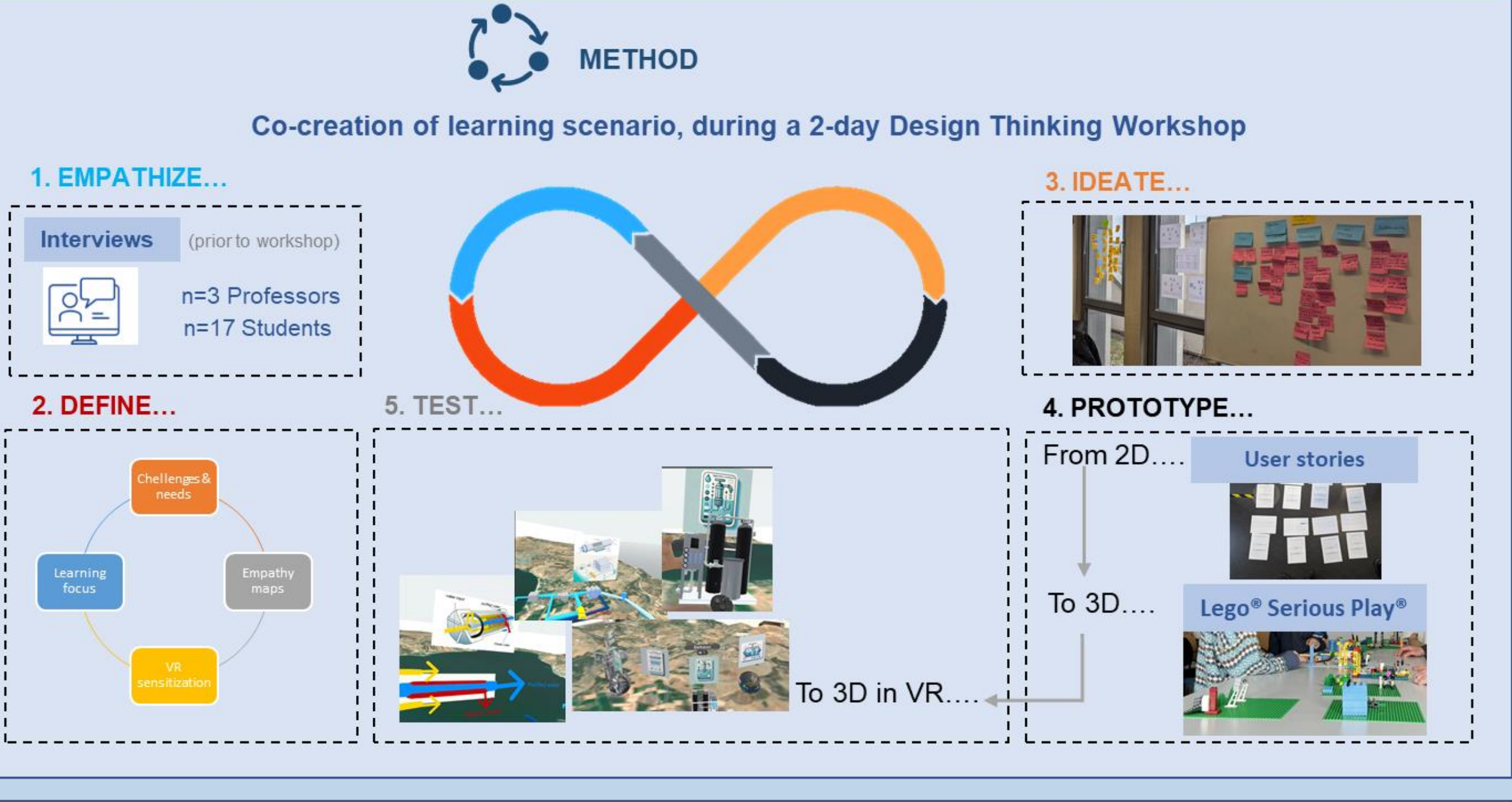
CONTENT ADAPTATION TO EXPAND TO OTHER TARGET GROUPS

Expand to other target groups to **further knowledge dissemination** and **deepen understanding** about aspects of water resource management.

Potential target groups include **industrial training providers and high schools**.

Method

Co-creation of learning scenario, during a 2-day Design Thinking Workshop



1. EMPATHIZE... Interviews (prior to workshop) n=3 Professors n=17 Students

2. DEFINE... Challenges & needs, Learning focus, Empathy map, VR user experience

3. IDEATE...

4. PROTOTYPE... From 2D... User stories, To 3D... Lego® Serious Play®, To 3D in VR...

5. TEST...

CO-CREATION PARTICIPANTS

- n=8 MSc students (RWTH Aachen)
- n=2 Professors/lecturers (RWTH Aachen)
- n=3 VR experts (RWTH Aachen)

[6]

References:

[1][2] "Desalination". Lecture by Univ. Prof. Dr.-Ing. Nacken and M.Sc. F. Balmes, Institute of Hydrology, RWTH Aachen, M.Sc. Study Program Sustainable management – Water and Energy, November 2024.

[3] "Water-Food-Energy Nexus". Lecture by Prof. Dr.-Ing. H. Sewilam, Institute of Hydrology, RWTH Aachen, M.Sc. Study Program Sustainable management – Water and Energy, Moodle resources, 2024.

[4] RWTH Aachen, Institute of Hydrology, Co-creation workshop 01/2025. Image credits: H. Nacken, RWTH Aachen.

[5] [6] RWTH Aachen, Institute of Hydrology, Co-creation workshop 01/2025. Image credits: H. Nacken, RWTH Aachen.

[7] AI generated image. URL: <https://www.midjourney.com/>

[8] Tapprage Maximizing Energy and Water Efficiency in Seawater Desalination: IN-TA-CT® for Reverse Osmosis Seawater Desalination Plants. URL: <https://www.tapprage.com/anwendungsfelder-produkte/efficiency-in-energy-and-water-meerwasserentsalzung/in-ta-ct-bei-meerwasserentsalzung-durch-umkehrosmose/>

[9] MyScore Desalination scenario, RWTH Aachen. URL: <https://ifi.rwth-aachen.de/projekt/swem/>

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GEFÖRDERT VOM



Bundesministerium für Bildung und Forschung

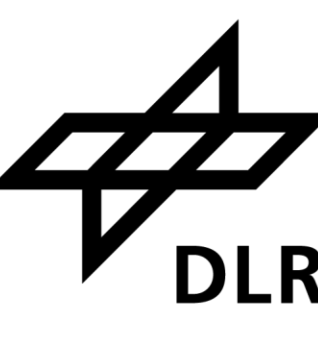
Project partners



Ernst-Abbe-Fachhochschule Jena Hochschule für angewandte Wissenschaften



CONSENSIVE



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