# CASE PRACTICE 5: WATER FOOTPRINT IN OUR VIRTUALITY

## 5.1 Overview

This Case Practice investigates the hidden and indirect water consumption utilized by digital technologies and AI. While climate issues are focused on carbon emissions, this project shifts the focus toward the largely invisible, yet critical issue of freshwater use in many areas (e.g., digital infrastructures, manufacturing processes, semiconductor production, data centers, and AI systems). This Case Practice was developed by Grade 11 students at Doukas School in Athens Greece and structured through a Hybrid Competition Model integrating the 5E/6E Instructional Model, and Design Thinking Model. Through this interdisciplinary approach, students can progress from awareness and problem framing to research, innovation, prototyping, evaluation, and final communication. The Practice combined scientific research, community engagement, technological innovation, and sustainability advocacy, culminating in:

- Structured research report.
- Awareness campaigns within the school community.
- Prototype concept for the interactive app “Visualizing the Invisible”.
- Exploration of immersion cooling as a sustainable engineering solution.
- A measurable project water footprint.

This Case Practice exemplifies applied STEM education aligned with sustainability, digital ethics, and environmental responsibility.

## 5.2 Learning/Teaching/Facilitating Plan (LTF)

**Case Practice Identity**

**Project Title:** Water Footprint in our Virtuality

**Driven question**: In what ways can we transform our everyday digital and AI activities ‘Visualizing the Invisible’ water footprint in schools and communities?

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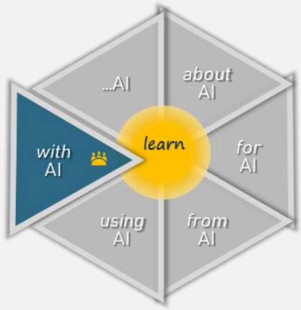

*Fig. 11.18: Dimensions & aspects of the practice*

**PILLAR 1: Educational Dimensions: LEARNING**

The Learning Dimension addresses the enhancement of students’ AI literacy within academic and societal contexts, enabling them to act as informed, productive, and responsible future citizens.
In this Case Practice, students:

- Developed critical AI literacy, understanding the material infrastructure related to digital and AI systems.
- Investigated indirect water footprints associated with AI prompts, streaming, cloud storage, semiconductor production, and data center cooling.
- Strengthened systems thinking skills, connecting digital behavior with ecological consequences.
- Practiced data analysis and interpretation through questionnaire design and statistical evaluation.
- Cultivated ethical digital awareness, reflecting on personal and collective digital habits.
- Engaged in STEM-based inquiry, integrating environmental science, engineering, physics, and computing.

It should be noted that AI literacy was not approached merely as operational competence, but as ecological-technological literacy, linking algorithmic systems to planetary boundaries.

**PILLAR 2 – Domain/Context: WITH AI**

AI was leveraged as:
- A research assistant (text generation prompts).
- A content development tool (AI-generated images and video motion elements).
- A planning and structuring support system.
- A creative ideation facilitator
- A personized study facilitator
- A collaborator

The Case Practice critically examined AI itself as a:
- Resource-intensive infrastructure.
- System requiring freshwater cooling.
- Contributor to hidden environmental externalities.

Thus, AI functioned simultaneously as a:
- Tool for knowledge production.
- Subject of sustainability critique.
- Medium for awareness dissemination.

As a result, it reinforces reflexive AI literacy.

**PILLAR 3 – Ethical Features and Elements**

- **Human-Centered Foundations:** The Case Practice integrates environmental science, engineering, computing, social sciences, and ethics. This transdisciplinary design reflects real-world complexity. The driving question connects daily digital behaviors of students to global water systems, ensuring relevance. In addition, the students acted as researchers, designers, evaluators, and communicators. AI tools were used under human guidance. Students critically evaluated outputs and retained decision-making authority.
- **Responsibility and Transparency:** Students assumed responsibility for communicating ecological implications clearly and promoting sustainable digital habits. Transparency extended to both technological and research processes.
- **Safety and Safeguarding:** AI tools were used in controlled educational settings. Content creation adhered to school guidelines and data collected through questionnaires ware anonymous and used exclusively for educational purposes. Finally, the Practice avoided misinformation and ensured scientifically validated sources.
- **Locality and Globality:** The initiative started in the Doukas School community, but addressed global water stress and AI infrastructure impacts. Water scarcity disproportionately affects vulnerable regions. By raising awareness locally, students addressed global inequities in freshwater distribution.
- **Role of Assessment and Evaluation**: The Case Practice evaluation included awareness change and community engagement as well as conceptual explanations (e.g., watre footprint, water stress and gap, immersion cooling). In addition, app structure were refined after peer feedback.
- **Compliance:** The Practice complied with school competition guidelines and academic integrity standards. Policy compliance to data privacy and intellectual property, and the models responsible for AI usage were based on ecological accountability within educational innovation.
- **Equity and Access:** All students (Grades 7–12) were included in awareness activities and information was presented through multiple formats ensured accessibility across learning preferences.

**PILLAR 4 – Innovation, Sustainability & Societal Impact**

- **Technological Solution:** The app used transformed abstract data into experiential visualization. This innovation merges gamification, environmental literacy, and systems modeling. Also by integrating engineering solutions, the Practice extends beyond awareness into applied sustainability.

- **Societal Impact:** Increased awareness within the school community, encouraged responsible digital consumption.

**PILLAR 5 – Reflection, Global Alignment and Transformative Outlook**

The Case Practice challenges  the techno-optimistic neutrality and reframes AI as materially grounded infrastructure. Students moved from passive digital users to critical digital citizens and to sustainable innovators . By "Visualizing the Invisible," they exposed hidden ecological costs and advocated for responsible innovation. Case Practice demonstrates holistic SDG integration and full activation of the 15 modalities through:

- AI literacy development.
- Sustainability-centered STEM inquiry.
- Ethical technological reflection.
- Community-based impact.

That represents a systems-level educational model linking digital innovation with planetary responsibility.

### 5.3 Content/Curriculum (Areas of Interest)

The **Action Plan** of this Eco-Vision Practice was structured using a Hybrid Competition Model (5E/6E and Design Thinking) for its development, moving from awareness and research to innovation, development, evaluation, and final report as well as communication by transforming a hidden environmental issue into a structured competition-ready sustainability Practice having the following phases:

**Phase 1: Engagement and Framing** (Engage – Empathize – Define the Challenge)

- **Trigger Event & Inspiration:**
  - Attendance at the EMFAF Practice event "Blue Career Centre for Aquaculture". The educational aspects were supported by a gamification approach and distance learning platform at the Agricultural University of Athens (Nov. 2025).
  - Initial engagement with the topic of "Water" as the base of the Practice.
- **Problem Framing:**
  - First team meeting. There was a brainstorming meeting of the team for the water related sustainability issues. Students created an Initial list of the following possible topics: Aquaculture (Overfishing), Microplastics in Water Shortage, Rising Water Levels, Water Acidity, Toxic Waste in Water, Great Pacific Garbage Patch, and Water Consumption by Technology and AI
- **Competition Requirements Analysis:**
  - Competition guidelines. Students identified a sustainability issue in the community, proposed an innovative solution relevant to SmUCS and STEM, and described a positive impact.

**Phase 2: Research & Analysis** *(Explore – Investigate – Analyze the Problem)*

- **Comparative Topic Research**
  - Students focused their research on two shortlisted topics: first, Microplastics in water; and second, Water consumption by technology and AI
  - An analysis and information gathering of the two topics was conducted
- **Final Topic Selection**
  - Decision to focus on "Water Consumption by Technology and AI"
  - Criteria for recent topics of concern, which were highly relevant, appealing and innovative. Strong connection to digital habits of young people.
- **Deep Research Period** (Dec. 2025)
  - Extensive research on the subjects of water footprint, water stress, water gap, data center cooling, immersion cooling, and digital water consumption.

- Collection of data, statistics, and references.
- Structuring of report content and main sections.

**Phase 3: Ideation, Concept Selection and Design** (Explain – Ideate – Engineer Solutions)

- **Solution Design A: Awareness-Based Solution**
  - Community Involvement and Awareness.
  - School questionnaire (7th–12th grade).
  - School posters.
  - Classroom visits.
  - Interactive awareness actions.
- **Solution Design B*:* "Visualizing the Invisible" based Innovative Solution**
  - Tech digital task collections for "invisible water".
  - Interactive water journey map.
  - 3D virtual data center exploration.
  - Water footprint calculator.
  - Immersion Cooling as sustainable technological solution.

**Phase 4: Development *(Elaborate – Prototype – Creation)***

- **Awareness Tools Creation**
  - Design and distribution of questionnaire.
  - Collection and analysis of student responses.
  - Creation and placement of school posters.
  - Classroom presentations.
- **Production**
  - Report writing (definitions, data, community actions, app structure, innovative solutions, references).
  - Creation of required 1-minute TikTok-style video.
  - Brief presentation of sustainability issues, innovative solutions, and positive impacts.
- **App Concept Development**
  - Structuring the four interactive stages.
  - Designing the map layout (consumption hub-school, data center and processing, and content delivery network).
  - Development of a playful demo app concept.
- **Artifacts Produced**
  - Development of questionnaires and quizzes.
  - Creation of an interactive infographic and presentation.
  - Classroom activities.
  - Development of demo app.
  - 5-page report.
  - 1-minute video.

**Phase 5: Evaluation & Iteration** (Evaluate – Reflect – Improve)

- **Community Feedback**
  - Analysis of questionnaire results.
  - Discussions in the classroom.
  - Peer interaction and awareness measurements.
- **Refinement**
  - Clarification of explanations on a set of issues (e.g., water footprint, water stress, immersion cooling).
  - Improvement of video clarity and messaging, including AI-generated 3D motion.
  - Alignment with competition requirements and SmUCS/STEM relevance.

**Phase 6: Final Report and Communication** (Communicate – Present – Deliver)

- **Submission** (30 Jan. 2026)
  - Final report completed.
  - Video finalized.
  - All deliverables submitted on January 30th.
- **Project Footprint Measurement: About 350 L - 700 Water Bottles** (500 mL)
  - AI text generation: ~500 prompts, AI Image creation: ~90 images, AI video calling: ~30 hours, video streaming: ~25 hours, data storage (80 GBs) (Fig. 11.19).
- **Communication of Impact**
  - Presentation of Water-Aware Digital Policy and "Visualizing the Invisible" of the case practice.
  - Emphasis on sustainable habits (e.g., water conservation, responsible digital habits, protection of natural resources).

Since students were already familiar, through their Informatics course, with the concept of a **Decision Table**, they deliberately employed it as a structured decision-support tool during critical stages of the Practice's development process. A representative example is presented below: the comparative evaluation that led to the final selection of the topic, following the shortlisting of two alternatives. By applying the non-weighted decision matrix with 4-level evaluation scale, students were able to reach a well-justified conclusion based on qualitative criteria translated into structured evaluation logic. Importantly, they did not consider it necessary to restructure the table into a weighted matrix to achieve stronger strategic differentiation, as the outcome of the initial comparative model was already sufficiently clear.

| # | Evaluation Criteria | Water Consumption by Technology-AI | Microplastics in Water |
|---|---|---|---|
| 1 | Emerging global concern | Definitely YES | Definitely YES |
| 2 | Strong relevance to students' digital habits | Definitely YES | Definitely YES |
| 3 | Strong integration with STEM & SmUCS | Definitely YES | Rather YES |
| 4 | High innovation potential | Definitely YES | Rather YES |
| 5 | Enables measurable community-level intervention | Rather YES | Rather YES |
| 6 | Low public awareness of the issue | Rather YES | Rather NO |

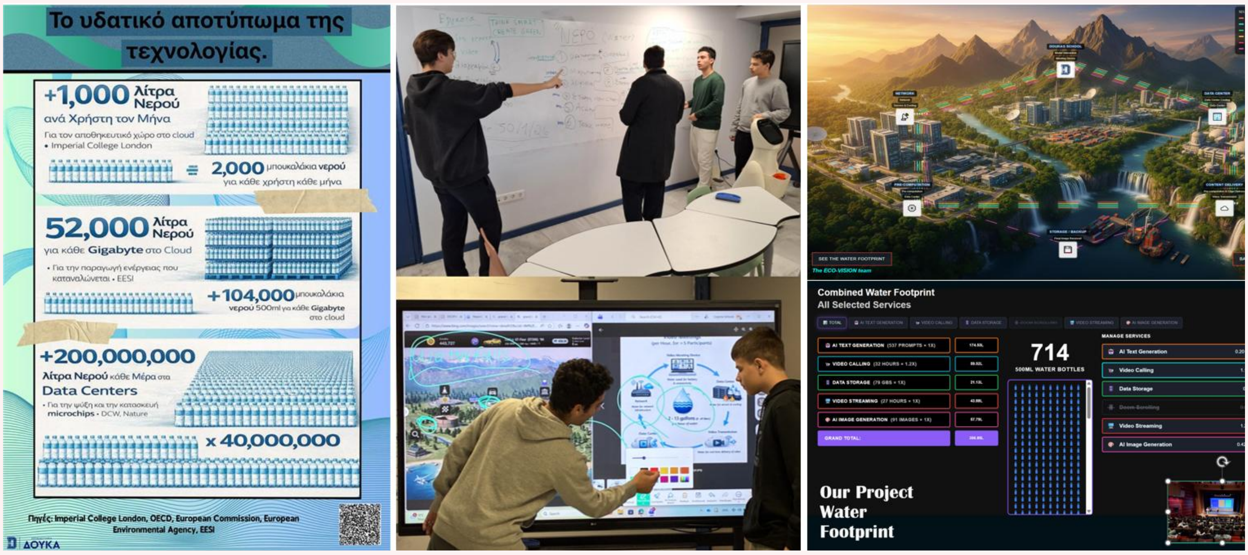


*Fig. 11.19 Snapshots from the progress of the Project and Screens from the Apps devepoped by the students*

**Executive Summary**

**Introduction** (description of the issue, key words and definitions)

The mass water consumption by technology, including AI, is an issue that is spiraling out of control in recent years, given the continuing increase in the use of technology in almost every aspect of our daily life. Without us even knowing or seeing anything, large amounts of much needed water is wasted. Such cases are: the use of our phones daily for many hours, the regular use of technology in schools and in the workplace, and the consumption of massive amounts of water to cool down data centers necessary for the provision of AI. For example, the creation of a smart phone requires about 12.075L of water; for a computer or a laptop, 190KL of water are needed, the creation of semiconductor chips needs 2.200L of pure water, while AI consumes every day nearly 200ML of water to maintain and cool AI data centers. That is, technology requires clean water to develop and operate its systems, and at the same time there is limited water supply for everyday human use and technology, creating what is known as water stress, which refers to human needs for water in relation to the actual availability of water. Actually, countries with water stress have water availability per person, less than 1,700 cubic meters of clean water per capita. The water stress has become a real issue for many communities around the world, as humans extract eight times more water than a century ago. Humans are using more water than the water cycle can provide, depleting aquifers and threatening ecosystems and wildlife. As a result, the water footprint, which is the both the direct and indirect total volume of freshwater used to produce goods and services is a major local, regional and international problem. Moreover, nowadays there is the appearance of the water footprint of technology, which is mainly indirect, because the water is consumed behind the scenes for manufacturing devices, operating technology and cooling data centers.

**Community Involvement and Awareness** (questionnaire and school posters)

As water waste becomes a global issue, informing and spreading awareness to young people is one of the most important aspects of solving this problem. In the Doukas school in Athens Greece a questionnaire was created, which was shared with young people from 7th grade up to the 12th. The collected statistics have shown that over 50% of teenagers do not know that technology uses such large amounts of water and around 60% are unsure whether they would change any of their personal habits to save water. In addition to that, posters were designed, created and put up in all school classrooms to spread awareness and draw interest about this sustainability issue. All classrooms from 7th up to 12th grade were visited an and talked about the sustainability issue that the case practice is addressing. With these actions, young people became familiar with water waste, water stress, water footprint and the water gap.

**"Visualizing the Invisible"** (game concept on water footprint)

One effective way to make the invisible path of water visible, raise awareness and help students understand how much water their everyday online actions consume, it can be accomplished through the creation of an appropriate app. In this way students by "Visualizing the Invisible" allows them to follow a personalized journey through four interactive areas: first, students select a tech task (e.g., video streaming, video calls, doom scrolling, data storage, AI text generation or AI image generation); second, an interactive map is created revealing the journey of the water consumed by the selected task, visualizing how this water travels through different locations and infrastructures; third, the students by entering in a 3D virtual world that works like a field trip inside a data center, can explore the hidden water footprint and see how water flows through different systems; and fourth, students calculate the water footprint, by creating a complete breakdown of how much water goes into each category and the total amount of liters of water spent, with an image showing how much water is spent if it was used in water bottles.

**Immersion Cooling** (innovative solution)

Addressing the problem requires not only awareness but also concrete technological solutions. Immersion cooling is an innovative method of cooling IT hardware, servers or data centers by fully submerging them in a thermally but non-conductive liquid. Unlike water cooling, immersion cooling allows the liquid to come into direct contact with the servers without causing damage, removing heat faster, more efficiently and much more sustainably. There are two types of immersion cooling. Single-phase immersion cooling is the method in which the coolant never changes state and remains in liquid form. Two-phase immersion cooling, also known as evaporative cooling, allows the working fluid to exist in either liquid or gas state, taking advantage of latent heat. By implementing immersion cooling, we focus on minimizing water waste and usage by technology and AI.

**Positive impact**

With the implementation of the: water-aware digital policy, awareness actions, "Visualizing the Invisible" app, and using immersion cooling as a sustainable substitute for water, students concluded that the measures utilized have a positive impact on solving the issue of mass water consumption by technology and AI. By sharing questionnaires, visiting classrooms and creating posters, informing their peers they were helped to get a better understanding of what technology requires to function and the urgent need to find a sustainable solution. The creation and use of their app can help students and in general any person to interact and see how much water they consume, encouraging more responsible digital habits. Reducing the water consumption associated with technology and AI helps protect natural resources and supports long-term environmental sustainability. By minimizing water consumption and referring to this issue, it is hoped that our Earth will become a more sustainable place with a brighter future.

*Note: The Students' 5-Page Report "THE MASS WATER CONSUMPTION BY TECHNOLOGY & AI" are one of the five innovative SmUCS and STEM solution selected by the Greek Agency for the 6th EU-CONEXUS International School Contest "Think Smart, Create Green" (National Results: 27 Feb 2026) and the Student Developed Application: https://visualisingtheinvisible.com*

**Sources** *(according to Students' 5-page Report)*


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- A cloud in need of water (2023): www.wearewater.org/en/insights/a-cloud-in-need-of-water/

### 5.4 Aspirations (Sustainable Development Goals)

The following goals of the Case Practice are connected with the 17 United Nations Sustainable Development Goals (SDGs):

- **SDG 1: No Poverty:** Although not directly poverty-focused, the project highlights how water scarcity disproportionately affects low-income and vulnerable communities. Reducing hidden water consumption in digital infrastructures contributes indirectly to mitigating resource inequality.
- **SDG 2: Zero Hunger:** Water scarcity impacts agriculture and food systems. By addressing excessive water use in AI and technology, the case practice supports sustainable freshwater allocation that safeguards food production systems.
- **SDG 3: Good Health and Well-being:** Water stress threatens sanitation, hygiene, and ecosystem health. Promoting responsible water use in technological systems contributes indirectly to healthier environments and communities.
- **SDG 4: Quality Education:** The case practice exemplifies innovative, interdisciplinary STEM education, integrating AI literacy, sustainability awareness, and critical systems thinking within authentic learning contexts.
- **SDG 5: Gender Equality:** Digital access and environmental impacts intersect with gender equity globally. By promoting equitable digital awareness and sustainability literacy across all students (Grades 7–12), the project fosters inclusive participation in STEM and environmental discourse.
- **SDG 6: Clean Water and Sanitation:** This is the primary SDG alignment. The case practice directly addresses freshwater consumption, water stress, water gap, and sustainable water management within digital infrastructures.
- **SDG 7: Affordable and Clean Energy:** Data centers require both energy and water for cooling. By promoting immersion cooling and efficient infrastructure, the project indirectly supports cleaner, more efficient energy-water nexus systems.
- **SDG 8: Decent Work and Economic Growth:** The case practice encourages sustainable technological innovation. Responsible AI development ensures that economic growth in digital industries does not undermine ecological stability.
- **SDG 9: Industry, Innovation and Infrastructure:** Indicate strong alignment in Analysis of semiconductor manufacturing, Data center cooling technologies, Proposal of immersion cooling innovation and Sustainable digital infrastructure design.
- **SDG 10: Reduced Inequalities:** Global water scarcity disproportionately affects regions with limited infrastructure. Addressing hidden water consumption in high-tech economies supports more equitable global resource distribution.
- **SDG 11: Sustainable Cities and Communities:** Digital infrastructures are embedded within urban ecosystems. Therefore, promoting water-aware digital policies contributes to more sustainable and resilient communities.
- **SDG 12: Responsible Consumption and Production:** The case practice central alignment reframes digital behavior as consumption with environmental consequences, promoting responsible digital habits and systemic efficiency.
- **SDG 13: Climate Action:** Water and climate systems are interlinked. Sustainable data center cooling and reduced water extraction contribute to climate resilience and ecosystem preservation.
- **SDG 14: Life Below Water:** Reducing water over-extraction protects aquatic ecosystems and reduces pressure on freshwater and marine systems.
- **SDG 15: Life on Land:** Overuse of freshwater threatens terrestrial biodiversity. Responsible technological water management protects land-based ecosystems.
- **SDG 16: Peace, Justice and Strong Institutions:** Transparency in AI infrastructure and resource accountability strengthens institutional responsibility and ethical governance in technology sectors.
- **SDG 17: Partnerships for the Goals:** The case practice integrates School community engagement, Interdisciplinary collaboration and demonstrating partnership-based sustainability action.

### 5.5 Reality (Modalities and Non-Neutrality)

**Modalities:** The project provides a concise explanation of how it is aligned and activates each of the 15 Modalities (Dooyeweerd 1958), as shown next.

- **Scientific Modality:** Grounded in environmental science, hydrology concepts, and thermodynamics (cooling systems).
- **Technological Modality:** Explores AI systems, data centers, semiconductor production, and immersion cooling engineering.
- **Engineering Modality:** Applies the engineering design process to propose immersion cooling as a sustainable alternative.
- **Mathematical/Quantitative Modality:** Includes data analysis from questionnaires and estimation of water footprints (250–300 L project footprint).
- **Environmental/Ecological Modality:** Creation of centers on freshwater scarcity, aquifer depletion, and ecosystem protection.
- **Ethical Modality:** Critically examines technological neutrality and responsibility in AI development.
- **Social/Civic Modality:** Engages the school community through awareness campaigns and classroom discussions.
- **Economic Modality:** Considers resource extraction costs and industrial water usage in global tech manufacturing.
- **Political/Policy Modality:** Addresses water governance, transparency in digital industries, and sustainable infrastructure regulation.
- **Cultural Modality:** Challenges digital culture norms such as excessive streaming, data storage, and AI overuse.
- **Digital Literacy Modality:** Enhances students' ability to use AI tools critically and responsibly.
- **Systems Thinking Modality:** Connects digital habits, industrial production, cooling systems, and global water cycles.
- **Creative/Innovative Modality:** Designing the "Visualizing the Invisible" interactive app concept and gamified the awareness model.
- **Communication Modality:** Includes posters, presentations, video production, infographics, and public dissemination.
- **Reflective/Metacognitive Modality:** Students measured their own water footprint, reflecting on their digital impact and refining outputs after evaluation.

**Neutrality:** The project directly reflects Kranzberg's law: "technology is neither good nor bad; nor is it neutral". In this case, Artificial Intelligence was used by students not only as a helpful tool, but as an "expert collaborator" to assist with research, to generate visuals, and to support their project. However, the same technologies they used also have unseen environmental consequences, such as the large amount of water needed to cool data centers or to produce digital devices. This contrast shows that the effects of technology depend on how it is used and understood in society. The students are now fully aware of the water footprint of their own actions in this project and in their life. The project highlights that technologies are not separate from human goals and decisions that they are shaped by social values, design choices, and real-world impacts. It also reveals that even everyday digital activities, like watching videos or storing files online, can lead to environmental stress, showing that technology is never completely neutral or harmless in its influence.