DIGIWATER

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R2.1.2 REPORT ON BEST PRACTICES IN TEACHING DIGITAL WATER SUBJECTS

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1. INTRODUCTION

The aim of this activity WP2 is to update water education programs with digital subjects and to add new training courses in the field of innovation and entrepreneurship.

In order to achieve the proposed objectives, were analysed within the task T2.1.2, the best practices for teaching and training of the important topics of water digitization as well as the existing collaborations between the members of the consortium but also between the members and other entities outside it.

The results obtained in these activities should help us in opening a new perspective for curriculum development and improvements in collaboration with enterprises.

This report contains the answers of the consortium members to three important questions:

1. Relevant examples for Best practices in teaching / training digital water relevant subjects (IoT & and Big Data, Cybersecurity in Critical Water infrastructure).
2. University - Enterprise collaborations outside the current consortium.
3. University-enterprise collaborations inside the current consortium.

This activity will result in a full presentation of best practices in teaching water-relevant digital topics and existing university-enterprise collaborations inside and outside the current consortium.

2. BEST PRACTICES IN TEACHING/TRAINING

To the question regarding the Best practices in teaching/training of the digital water-relevant subjects (IoT and Big Data, Cybersecurity in Critical Water infrastructure) in your University / Enterprises, partners responses were:

2.1 P2 - Technische Hochschule Ostwestfalen-Lippe (THOWL)

- Use of simulations in teaching for a better understanding of processes as well as for process optimization, decision-making (simulation objects: e.g. wastewater treatment plants, precipitation runoff, rainwater use).
- Teaching data literacy in the context with climate change and other environmental sets of data

2.2 P5 - Katholieke Universiteit Leuven (KUL)

- Data-based modelling is only partly addressed in some of the courses of our Master programs of Civil Engineering: Hydraulic Engineering and Master of Water Resources Engineering.

Examples are data-based modelling in systems approach to water management course; data-based modelling of urban drainage and river systems in urban hydrology and hydraulics course.

- IoT and Big Data based approaches have been applied by some students in their master and PhD thesis research.

Examples are the master and PhD studies on rainfall input modelling combining data from different sensors including crowdsourcing data; on self-learning hydrological and water balance models; on AI-based forecasting models for floods, low flows and groundwater.

2.3 P7 - University of Cyprus (UCY)

- PHOEBE (PHOEBE Research and Innovation Ltd) is not focusing in the teaching of water relevant subjects to students of any age, however, we do offer training to professionals in the water systems industry, to enable them effectively adopt our analytics solutions. We have the following two products in the water systems:

i) LeakRisk™ - www.phoebeinnovations.com/leakrisk, a smart reporting engine for water distribution network operators, based on real-time system monitoring using low-cost water-flow sensors. It analyses heterogeneous system data" from physical and/or virtual sources and produces reports indicating the risk of a leakage present in the system. The current

product version is at TRL 8-9, ready for contract signature and subsequent deployment to customers.

ii) Water Analytics Platform – www.wateranalytics.eu, A Web/Desktop Platform that facilitates the creation and management of Digital Twins of Water Distribution Networks and the smart monitoring and control of the networks. The platform enables the integration of smart measuring infrastructure and research-based algorithms, offering advance decision support capabilities to the water system operators for the optimization of the system operation and minimization of wastes or quality issues. The decision making is supported by machine learning algorithms. Currently at TRL5-6.

Both above products have been designed and developed in collaboration with the KIOS Research and Innovation Center of Excellence, University of Cyprus.

- **KIOS**, being a research organisation of an academic institution, does offer teaching/training tools related to water systems. Some excellent practices follow:

i) The 5 place game that creates an online challenge for people of any background, to place up to 5 water quality sensors in a given water network, trying to achieve maximum analytical coverage of the network for the detection of contamination events. The game is accessible at: https://www.smartwater2020.eu/5place/.

ii) Puzzle that challenges players to find the water dams, at https://smartwater2020.eu/puzzledamscy/

iii) An international competition which attracted research groups from top Universities and research organisations in the world. The objective was to create algorithms to minimize leakages in a virtual yet realistic water network, the one of L-Town. See at: https://www.smartwater2020.eu/?p=850

2.4 P9 - University of Galati (UGAL)

2.4.1 What is digital water?

After energy, it has now come the turn of water as utility to be valued. Helpful in this sense are the digital tools that have literally shifted the power to people. Thus, there are a number of digital platforms that make possible for people to schedule when best to run their appliances so that to reduce their consumption in real-time. But the digital water technologies are promising especially for water professionals in emerging economies. The discussion is the same old vs. new, expensive vs. cheap. Thus, as it has been demonstrated energy wise, the development and the transformation of digital technologies have the potential of solving some of the water challenges existing. The planet

struggle for resources and water is no exception. The digital water concept aims exactly at achieving a harmony between the urban, industrial, agricultural and ecological demands within a watershed and it has all the means to do it as the dynamic and data-driven (as opposed to mechanistic) models can help integrate and optimise smart pumps, valves, sensors and actuators, not to mention the vast capacity of transferring and accessing huge volumes of data via wireless connections which provide real-time information that can be made available even to the end user.

Therefore, in this context subjects such as IoT and Big Data and Cybersecurity in Critical Water Infrastructure are of great interest. IoT and Big Data are two concepts that cannot be separated as the first tells us how everything is connected starting from something as mundane as a toy and ending with a high-tech computer, while Big Data targets the act of accessing and storing large amounts of information. Cybersecurity in Critical Infrastructure is the immediate topic of interest when envisioning the digitalization of watersheds. The IoT and Big Data involved in the water infrastructure need protection and Critical Infrastructure is a term referring to all sensitive or essential assets for the functioning of a society. Thus, the joining of the two concepts, cybersecurity and critical infrastructure, is inevitable transforming it into an essential topic within aspects of national and international security as a failure in providing the adequate control could result into a debilitating effect on society.

In terms of teaching, whatever the subject may be, there are some general rules that must be followed in order to achieve the best pedagogical results. Thus, whether the focus is, for example in IoT and Big Data in digital water or Cybersecurity in Critical Water Infrastructure, the first step is to establish the content of the subject, the method and practice used in teaching, i.e. the pedagogy, and the type of assessment. Next, given the fact that these courses are intended to be delivered online and in digital format, special attention is to be given to the two types of learning involved in this kind of teaching and that is the alternation between the synchronous and asynchronous learning. In order to get the best out of this mix, there needs to be a careful planning of the content into video and non-video materials with the main focus on constantly engaging the students.

The basis of a successful teaching act lies in the strong emphasis on content (what are the core concepts that we want our students to learn?), pedagogy (what is the most effective way for the students to take all in and how do we want them to interact with the material?) and assessment (how can we best assess their understanding of the material?) which translates into:

- Clear expectations drawn with a detailed syllabus (you have a number of weeks allocated to the course therefore you have the same number of titles. The titles should be insightful.)
- Due dates and schedule (the schedule is constructed considering the weeks allocated to each course. The planned content of the course is then broken down into learning objectives which are attained via assignments clearly established with due dates)
- Clear assignments directions (the careful planning of the learning objectives, of the assessment and assignments translates into clear and precise directions intended to ease the knowledge acquisition process and result in completing successful tasks)
- Learning objectives (make sure that the course content is aligned with the objectives and the assessments. The content which is not directly supporting the learning objectives is to be removed or indicated as optional)
- Keep in mind the feedback (emphasize the important materials and concepts and incorporate timely feedback throughout the course)
- Be mindful of the online delivery of the course (divide the learning/teaching into smaller chunks with patterns of activity and due dates; describe the expectations in terms of online participation, communication and the netiquette; provide technical support and information)
- Engage the students (well thought educational experiences that are challenging become enriching and cultivate the academic abilities and also stimulate the interaction between students; create opportunities, through discussions and group work, for the students to interact with their peers)
- Keep in mind the real world (students need to constantly be motivated through connections with the real world, therefore they need guidance into discovering how the acquired knowledge is actually applied)

Although the residential and the online teaching follow the same best practice rules, planning the teaching material for online courses has its share of challenges and for a better delivery one must take into account certain specific aspects. The pedagogy remains the same only the instruments differ slightly. Thus, certain teaching techniques that are better performed during the residential teaching, such as ‘reading the room’, ‘cold calling’ and opening the floor to general discussion of particular questions, can still be used with the well-planned and intentional use of the online technologies. Therefore, one can enhance the engagement by:

- anticipating potential learner's questions regarding the material,
- 'reading the room' using questionnaires, polls or other interactive technologies, thus accessing the experience, comprehension and the reaction of the students
- inviting the students to answer questions that are well-thought and prepared in advance so as to provide the most understanding and challenging
- open the floor to general discussion and create 'buzz groups' conversations via breakout rooms
- use tools like Google Docs, Miro etc to create opportunities for synchronous and asynchronous student collaboration

2.4.2 Synchronous and asynchronous mix

The online teaching, just like the residential teaching, involves both the interaction teacher – student as well as the self-paced learning implied by assignments. However, some challenges of the online medium are still to be considered. Thus, the classical lectures cannot function here as long lectures do not work well in online teaching, as a result consider organizing the material into asynchronous content and break it into smaller sections. Keep in mind that using case studies as basis for discussion in class might reduce the need to create asynchronous materials.

For the synchronous learning, create and upload your materials using easy distributable formats such as pdf's and to save time consider pre-made templates. Also, break up text-heavy presentations, as, online, students tend to read first and listen second, organize well your course materials using canvas modules and integrate library resources and other digital materials.

For delivering your lecture consider the following:

- create a script of your lecture where everything is well fitted into time sequences, including the time allocated for group discussions or collaborative work between students
- practice makes perfect – if possible, try to practice, at least once, in advance as you need to joggle with a lot of features of the online teaching platform such as switching between the presentation mode, screen share mode, slides and other materials, whiteboard, questionnaires or videos
- be explicit in the transitions you make between activities and the discussion topics and avoid chaos
- be mindful of your pace and constantly keep an eye on the students' comprehension and engagement

When planning the synchronous learning, consider that not all students are able to attend the online class and be prepared for potential technical difficulties. Thus, recorded and pre-recorded materials can help. “Although they are time consuming, creating pre-recorded lectures allow you to edit the recordings and integrate graphics and animations. They prove themselves extremely useful when the live sessions experience unexpected bandwidth problems. Here are some tips on how to organize your pre-recorded material:

- outline the content you intend to cover
- break down the lecture into shorter segments of no more than 3-5 minutes
- intersperse the lecture clips with reflection questions, polls, action prompts and other interactive elements. Keep in mind that the experience should be inductive rather than entirely didactic
- add your personal touch – a personal story, humour or editorial commentary

The pre-recorded material can complement beautifully the live session, therefore, consider pre-recording certain segments of your lecture (some material you want the students to reflect upon before the class, or an explanation of key terms or concepts) and leave the rest for the synchronous sessions”. (teachremotely.harvard.edu)

2.4.3 How to make the best out of your online lecture

One of the disadvantages of the online teaching is the disengagement the students feel. Thus, it is important for the instructor to create peer communities both at the level of an activity and the course and to think of the online course not only in terms of how to best deliver the content but also how to create an intellectual community. To this end, a review of the course activities is recommended so as to identify which can bring students together in peer groups. Special attention must be paid to the organization of this type of activities too, as there is the risk of some students feeling isolated. Therefore, it might be better for the teacher to assign the groups creating them more intentionally and making sure that all students are included and treated equally. Instead of trying to replicate the classical residential teaching, embrace the numerous possibilities given by the online world. As everything is just one click away both the synchronous and the asynchronous learning can become interactive and the many online formats (it is important to understand that the learning process is enhanced as you create materials in different digital formats) give way to creating new learning experiences. The collaborative work is more accessible easing the connection between concepts and the real world. Everything is just one click away and so are experts. Inviting outside experts requires you to place the focus again on interactivity and avoid the lecture format. You can use experts as guests and in this case your role is to moderate the conversations. Finally, do not

focus assessments solely on the ability to remember and understand, instead transform it into a learning opportunity too. For this to happen, you need to plan assignments and assessments of different stakes (low and high stakes) and make the most out of the low stake ones as they can be an indicator of student comprehension and engagement.

Example on how to structure and organize the course

IoT and Big Data – online course

Duration – 10 weeks

Frequency – 3 times / week (2 h meetings, 3 days / week)

Organization – weekly modules, flexible learning

Objectives for the course

1. Grasping essential guidelines for the real-world implementation of IoT and Big Data
2. The ability to assess the technology integration, business wise, and to identify opportunities of enhancing it and provide strategic advantages
3. An understanding of the ways you can use IoT and Big Data in transforming and implementing new digital infrastructures

Week 1 – Title of module

Day 1 – introductory lecture using, ppt, video, pdf. Engaging the students into discussions using questionnaires, polls and cold calling

Day 2 – key concepts – ppt, video, pdf, Google docs etc. Create work groups and initiate peer collaboration

Day 3 – apply key concepts – ppt, video, pdf, google docs etc. Give clear assignment of low stake, even zero first, to be able to clearly grasp from the beginning the level of engagement and comprehension.

Week 2, 3, 4….10

Assessment

The assessment is continuously done by assigning tasks alternating between low and high-stake assignments. The final grade is made up following the formula 50% high stake assignments + 50% final project

Webliography:

teachremotely.harvard.edu

teachonline.asu.edu

The rise of digital water – thesourcemagazine.org

Big Data – What it is and why it matters – sas.com

3. UNIVERSITY-ENTERPRISE COLLABORATIONS OUTSIDE THE CONSORTIUM

Regarding the collaboration between universities and enterprises outside the consortium, the answers were:

3.1 P2 - Technische Hochschule Ostwestfalen-Lippe (THOWL)

- Finding of design data for a WWTP from operation data (3 years) based on statistical analysis
- Development of a model for integrating TSS in stormwater management models
- Implementation of simulation tool for better understanding of P-removal and reuse processes

3.2 P5 - Katholieke Universiteit Leuven (KUL)

- PhD research at KU Leuven on smart regulation of flood control reservoirs i.c.w. Flemish Environment Agency (VMM).
- Research on smart regulation of green roof with city of Antwerp and company Vegetal i.D., as tested innovation in EU-H2020 project Brigaid.

3.3 P7 - University of Cyprus (UCY)

PHOEBE and KIOS-UCY have a long and successful collaboration in water systems, which started in 2016. The aims of the collaboration are to commercialise the state-of-the-art research undertaken within the research center and the IP it produces. The Water Analytics Platform is maybe one of the very few examples in EU where at least 10 science-based algorithms have been "translated" to intelligent services (smart water apps) and offered to water system operators for their use.

PHOEBE is also collaborating with a number of other EU research organisations in water related projects. See the projects:

i) PathoCERT (https://pathocert.eu/) which deals with emergency response in water-related incidents, and

ii) WQeMS (https://wqems.eu/) which offers Copernicus-based services to support the emergency response processes.

Partners of both projects are listed in the websites.

3.4 P9 - University of Galati (UGAL)

BIOCON Project (http://www.biocon.ugal.ro/)

The team involved in the project consists in four entities, each of them having a rich experience in conducting scientific research projects: Coordinator – University of Galati, P1 – University of Craiova, P2 – Polytechnic University of Timisoara and P3 – TeamNet Engineering ltd. The team consists in specialists in automation, process informatics, biotechnology, thus fulfilling the interdisciplinary characteristics of the project.

The main objective of BIOCON project is the experimental analysis and the efficiency increasing through automation methods of a complex plant of biorefinery type. The biorefinery plant consists in a coupling of two processes: an anaerobic digestion one and a microalgae photosynthetic growth process in photobioreactors. This plant is used for obtaining biomass from microalgae in order to produce components with added value, bio-mitigation of the CO2 emissions obtained from methane combustion and its use as a substrate for the microalgae photosynthetic growth process. At the same time, the use of the biomass residues as a substrate for the biogas production in the anaerobic phase and the process of methane obtaining in anaerobic fermentation processes are also studied. To achieve the project objectives with the available resources, a biorefinery plant having a structure based on a modern concept of HIL (Hardware in the Loop) has been adopted in the project. This structure means the coupling between an experimental structures (the photobioreactor for the microalgae photosynthetic growth process) with a software structure (the anaerobic digestor). It can be mentioned that the HILS structure used in the project behaves similarly to the experimental plant of biorefinery type.

4. UNIVERSITY-ENTERPRISE COLLABORATIONS INSIDE THE CONSORTIUM

Regarding the collaboration between the members of the consortium, the answers were:

4.1 P2 - Technische Hochschule Ostwestfalen-Lippe (THOWL)

- Cooperation with STEB for the access to operational data of sewer and WWTP with the goal of the implementation into lectures and exercises. A tool for data transfer and extraction from the SCADA-system is under construction Learning target: understanding of data management and its application for design and operation

4.2 P5 - Katholieke Universiteit Leuven (KUL)

- RainBrain cooperation between KU Leuven and Sumaqua, on smart regulation of rainwater storage systems for the Slimme Regio call of the Province of Vlaams-Brabant in Belgium.

4.3 P7 - University of Cyprus (UCY)

- UCY is our partner in Water Analytics and it also coordinates the PathoCERT project.