DIGIWATER

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R2.3.2 TEACHERS/INSTRUCTORS AT PARTNER UNIVERSITIES/COMPANIES TRAINED

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v.01	20/04/2024	Initial report	STEB &SmarTech

Contents

1. INTRODUCTION

To achieve the goals of the DIGIWATER project, it started by examining how digitization is transforming the water sector and provided an overview of the current state of digital in the water sector. Analysis and documentation activities were carried out on the interests of the stakeholders of the digital water project by sector (academic, enterprises, government and society). The involvement of these parties in the project, interdependencies, influence and potential impact on the success of the project was defined. Planning for the involvement of interested parties, a specification and a quantification of their needs in the field of digital water was carried out.

With this information, an update of the water education programs with digital subjects was thought with the inclusion of training activities in the field of innovation and entrepreneurship. Thus, it was thought to design a curriculum relevant to the needs of the market and society. Based on this curriculum, teaching and learning materials have been developed that can be used in university or lifelong learning courses, both in the classroom and through eLearning. An e-learning platform was designed, developed and implemented to host the developed materials. Another goal was to train teaching staff from academia and companies and to test and implement the improved curriculum in partner universities.

Having these teaching and learning materials, in order to train the teaching staff and to implement the improved curriculum, training activities were carried out for trainers as well as training activities at the partners' headquarters.

2. TRAINING OF TRAINERS AND TRAINING AT PARTENERS

A training session was organized that included the topics for each of the two courses. In the session for the IOT course, a summary of the course modules was presented. For the BigData course, a Big Data Analytics module was presented. The session was monitored through the Mentimeter platform and the presentations were made online using the ZOOM platform.

This session of training was attended by course editors, other project partners and interested persons outside the project.

2.1 Training Materials

The training materials for the trainers were designed starting from the two important concepts in the water digitization process that also represented the subjects of the two courses developed within this project. These materials cover the two relevant topics: Internet of Things (IoT) and Big Data.

Each topic is detailed in a separate course, which in turn is divided into a series of modules covering sub-topics relevant to the two digitization areas. These course modules are used in train the trainers sessions and in university and company training.

2.1.1 Training materials for IOT course

The IOT course presents the main topics related to the Internet of Things applicable in the water industry, a system of physical and virtual objects interconnected with sensors, processing and

communication skills, which can interact with each other as well as with other devices and systems through the Internet or other types of networks.

The component modules of the course are presented in the following table.

Table 1 - IOT Modules and Trainers

Unit	Module	Partner	Trainer
A1	Introduction to IoT	UCY	Andreas Naziris
A2	Sensors in IoT	DOSCON	Abhilash Nair
A3	Instrumentation and SCADA	SMARTECH	Laurentiu Luca
A4	Cyber Security in IoT	UGAL	Marian Craciun
A5	Standards & good practices (incl. Legal framework)	NMBU	Katharina Pilar von Pilchau
A6	Case studies based on simulations	SumAqua	
A7	Future trends	NMBU	Harsha Ratnaweera

The details of the content of the training materials for the modules of the IOT course and the expected results for these are presented below.

A1. Introduction to IoT
CONTENT:

- IoT - What is the IoT and why is it important? Elements of an IoT ecosystem, Technology drivers,
- Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues.
- IoT Protocols - Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and
- RFID Protocols – Issues with IoT Standardization – Unified Data Standards – Protocols –
- IEEE802.15.4–BACNet Protocol– Modbus – KNX – Zigbee– Network layer – APS layer – Security
- IoT Architecture - IoT Open-source architecture (OIC)- OIC Architecture & Design principles- IoT
- Devices and deployment models- IoTivity : An Open source IoT stack - Overview- IoTivity stack
- architecture- Resource model and Abstraction.
- Web of Things - Web of Things versus Internet of Things – Two Pillars of the Web – Architecture
- Standardization for WoT– Platform Middleware for WoT – Unified Multitier WoT Architecture –
- WoT Portals and Business Intelligence.
- IoT Applications - IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart
- Objects, Smart Applications. Study of existing IoT platforms /middleware, IoT- A, Hydra etc.

OUTCOME:

- Describe what IoT is and how it works today
- Recognise the factors that contributed to the emergence of IoT
- Design and program IoT devices
- Use real IoT protocols for communication

- Secure the elements of an IoT device
- Design an IoT device to work with a Cloud Computing infrastructure.
- Transfer IoT data to the cloud and in between cloud providers
- Define the infrastructure for supporting IoT deployments

A2. Sensors in IoT

CONTENT:

- Types of online sensors
- Sensor measurement principles
- Sensor calibration
- Communication protocols
- Enabling IoT on sensors

OUTCOME:

- Can develop a good knowledge of different types of online sensors used in water sector.
- Be able to describe various measuring principles used by online sensors to detect variations in water-quality parameters.
- Be able to describe the communication protocols used to read data from online sensors.
- Can demonstrate an understanding of appending an IoT enabled transmitter to a water-quality measuring sensor.

A3. Instrumentation and SCADA

CONTENT:

- SCADA Overview
- SCADA Architecture
- SCADA Hardware
- Instrumentation
- Networks
- RTU and PLC
- HMI
- Servers
- SCADA Software
- SCADA Security

OUTCOME:

- What is a SCADA system,
- Where these systems are used,
- Component of SCADA systems,
- How to choose system components,
- How to program these systems,
- Industrial communication networks within SCADA systems,
- Security threats for SCADA systems
- Ways to protect against these threats.

A4. Cyber Security in IoT

CONTENT:

- Introduction in Cybersecurity
- Security goals
- Cybercriminal categories
- Common threats. IoT threats
- Cyberattack categories
- Security countermeasures.
- Access Control

- Physical security
- Security services
- Multi-factor authentication
- Reduction IoT security threats
- Cyber kill chain. IoT attack lifecycle
- Cybersecurity best practices and guidelines
- Incident response
- Disaster recovery
- Risk management

OUTCOME:

- Increase students' knowledge and readiness to defend themselves against cyber threats:
- understanding the world of cybersecurity and its importance
- understanding the most common cyber threats, attacks, and vulnerabilities and how they
- affect our data, network infrastructure, systems, and services
- understanding security countermeasures to protect data, networks, systems, and services
- using authentication, access control, encryption, backup, etc.
- understanding cybersecurity policies, procedures, and best practices for incident
- response, disaster recovery and risk management

A5. Standards & good practices (incl. Legal framework)

CONTENT:

The course covers relevant standards, good practices, and regulations of IoT

- IEEE and ISO/IEC standards and guidelines for IoT
- Architectural framework for IoT (IEEE P2413-2019), Harmonization and security of IoT (IEEE 1451-99), Sensor performance and quality (IEEE 2700, IEEE P2510)
- IoT security and privacy guidelines (ISO/IEC 27402), IoT trustworthiness Principles (ISO/IEC 30149 ED1), Interoperability for IoT systems (ISO/IEC 21823-1)
- Good practices for security of IoT
- Global overview of IoT regulatory frameworks (ITU, BEREC, ETSI, etc.)
- IoT security regulations (e.g., the EU cybersecurity act, the NIS2 directive) and IoT privacy regulations (e.g., GDPR)

OUTCOME:

- Develop in-depth working knowledge of existing policies, standards, and guidelines
- Outline and describe good practices related to the use of IoT
- Examine guidelines and standards related to cybersecurity for IoT products
- Develop a good knowledge of how the European Union (EU) regulates IoT cybersecurity and privacy
- Participate in policy debates about emerging IoT standardization issues and their regulation at domestic, European, and international levels

A6. Case studies using IoT and Big Data in the water sector

CONTENT:

- Different case studies showing how IoT (Internet of Things) and Big Data can support water
- management.

OUTCOME:

- Insight in practical applications involving digitalization in the water sector.

A7. Future trends of IoT

CONTENT:

- This module will include recent trends in IoT advances/innovations utilizing emerging technologies

- IoT Technology's growth
- IoT connectivity – 5G/6G, WiFi 6, LPWAN, and Satellites
- Empowered edge and fog computing in IoT
- Recent advances and applications of AIoT and Edge AI in cloud-based applications
- IoT-based smart cities
- IoT empowered predictive maintenance
- Blockchain for IoT security

OUTCOME:

- Explain current IoT applications, trends, and implications
- Understand where the IoT concept fits within the water sector and possible future trends
- Discuss IoT application usage in digital water and smart cities
- Describe IoT connectivity and networks
- Apply real-time and local analytics
- Appreciate the role of big data, cloud computing, and data analytics in a typical IoT system

2.1.2 Training materials for BigData course.

The concept of Big Data refers to data sets that are too large or complex to be treated by traditional data processing software and confers a potential immensity in the development of water systems management and the development of its infrastructure. The modules of this course aim to introduce students to the fundamental notions of Big Data and to present the various applications in the context of the increasingly accentuated digitization of the water and wastewater industry.

The component modules of the course are presented in the following table.

Table 2 - BigData Modules and Trainers

Unit	Module	Partner	Trainer
B1	Introduction to Big Data	KU Leuven	Daan Buekenhout
B2	Big data analytics (incl. Artificial Intelligence and machine learning tools)	UCY	Christos Markides
B3	Visualization of data	DOSCON	Viktoria Yavorska
B4	Cybersecurity in Critical Water Infrastructure	NMBU	Harsha Ratnaweera
B5	Data safety and standardization (incl. Crash course on Open data)	DOSCON	Aleksander Hykkerud
B6	Case studies IoT and Big Data	SumAqua	Kato Schoeters
B7	Data assessment exercises	TH OWL	Nataly Sivchenko
B8	Future trends	NMBU	Harsha Ratnaweera

The details of the content of the training materials for the modules of the BigData course and the expected results for them were summarized in the presentation and are presented in detail below.

B1. Introduction to Big Data

CONTENT:

- Motivation of the course content. Teasers/Example cases of state-of-the-art Big Data applications related to water.
- General definition of Big Data, goals and content of the course.
- Basic terminology: instances, features (numeric/categorical)
- Introduction to data types: structured, unstructured
- Introduction to types of algorithms: unsupervised, supervised
- Introduction to the data science workflow: problem statement, data sources, data selection, data
- cleaning, data transformation, analysis, interpretation
- Exercise session: hands-on application of the above on a water related problem and related dataset

OUTCOME:

- Understanding relevance and importance of Big Data for water applications
- Acquire general knowledge and experience in the domain of Big Data
- Grasping basic terminology and awareness
- First hands-on experience with real-life dataset

B2. Big Data analytics (incl. Artificial Intelligence (AI) and Machine Learning (ML) tools)

CONTENT:

- Introduction to Big Data - What is Big Data
- Introduction on Big Data processing and analytics and the challenges of Big Data mining
- Big Data Management
- Mining Data Streams & Streaming Analytics
- Big Data pre-processing
- Big Data Visualization
- Introduction to ML, supervised, unsupervised, reinforcement learning, hypothesis (models) spaces, examples of ML applications
- Introduction to AI, definitions and history of AI. Intelligent Agents: Problem formulation, goals, constraints environment and actors/agents.

OUTCOME:

- Acquire understanding of the sophisticated concepts and features of big data, ML and AI technologies and applications
- Acquire understanding of big data models, AI models, and their technical features, as well as build deep insights about what kinds of applications they can support
- Analyze the impact of advanced big data techniques for real-world business decisions and strategy applied in international companies.
- Acquire a complete and in-depth landscape of the history, development and various applications of AI in various real-world business sectors
- Master AI techniques, including knowledge representation and reasoning process techniques, and be able to apply them in business applications
- Develop skills in ML, such as linear regression, decision tree induction, and artificial neural networks, and be able to devise new real-world solutions by applying the skills.

B3. Visualization of data

CONTENT:

- Data representation
- Dashboards
- Tools for data visualization
- 3-D visualization and Virtual reality

- Web-based versus App-based

OUTCOME:

- Develop a good understanding of different types of data sets and way of visualizing them.
- Understanding the optimal dashboard layout for data representation.
- Analyze different visualization tools available in the market and identify the level of expertise required to use them.
- Understand the pros and cons of using a web-based visualization tool versus and app-based visualization tool.
- Demonstrate an ability to use tools to build basic dashboard layouts to visualize various datasets.

B4. Cybersecurity in Critical Water Infrastructure

CONTENT:

- Critical water infrastructure
- ICS/SCADA system security
- Security threats and vulnerabilities
- Real-world cyber incidents /examples of cyberattacks
- Cybersecurity standards and regulations (e.g., NIST cybersecurity framework, EU NIS2 Directive)

OUTCOME:

After completing this course, a learner/student will be able to:

- Develop a good knowledge of critical water infrastructure and its dependency
- Describe typical threats to modern water systems and outline techniques of defense against the threats
- Analyze critical water infrastructure and industrial control system security vulnerabilities and develop defensive measures
- Explain international cybersecurity standards and illustrate the context in which these are used to defend against cybersecurity threats
- Demonstrate an understanding of the specific regulatory and cybersecurity compliance requirements in the critical water infrastructure

B5. Data safety and standardization

CONTENT:

- Online databases and the communication protocols SQL NoSQL and hybridSQL
- Threats to data and data sensitivity
- Data security regulations
- Security layers and remedies
- Standardized data structures and formats

OUTCOME:

- Can recall different database technologies and communication protocols
- Can discuss different types of data, which threats they face and the damage these threats can cause
- Know that there are different regulations that need to be followed for different types of data in different parts of the world
- Describe steps to take for securing data and restoring data in case of data breaches
- Be able to understand the function and purpose of encryption
- Be able to discuss the need for standardized data structures
- Be able to plan a data structure to store data and examine already existing data structures

B6. Case studies using IoT and Big Data in the water sector

CONTENT:

- Different case studies showing how IoT (Internet of Things) and Big Data can support water management.

OUTCOME:

- Insight in practical applications involving digitalization in the water sector.

B7. Data assessment exercises

CONTENT:

- Interaction of water gauge and precipitation of different stations
- Example data assessment with R (can be reproduced by the students after the lecture)
- Procedure of data analysis
    - plausibility check
    - replacement of missing data by interpolation
- Correlation analysis to other data
    - visualization of two water gauges
    - correlation between data from two gauges
    - regression statistics for the correlation quality check
    - possibility of prediction
- Interaction with precipitation data
    - scripting of data transfer from html-pages (public assess)
    - assessment of water gauge changes resulting from precipitation

OUTCOME:

- Students identify access to public data
- Students are able to implement simple data analysis tools
- Students are able to assess data quality and interaction between data

B8. Future trends of big data applications in the water sector

CONTENT:

- Adoption of advanced analytics, machine learning, and other AI technologies increase
- Real-time big data analytics
- Advanced predictive analytics in the water sector
- Big data for improving monitoring performance and boosting efficiency
- Better water quality forecasting, prediction of water demand and supply
- Security and privacy for big data

OUTCOME:

- Describe applications of big data in the water sector
- Know about current research and industry trends of big data applications in the water sector
- Describe how big data analytics can solve problems in the water sector and other disciplines
- Optimize processes and create more accurate forecasting and predictive models
- Develop a good knowledge of the security and privacy of big data

2.2 Teaching and learning methods

The transfer of this knowledge is achieved through new teaching and learning methods. Thus, these courses are presented through an online platform, which contributes to improving the learning experience. The development of these courses was achieved by including case studies in the field of

IOT and BigData and each course module includes a set of practical activities. All these practical activities will be carried out in a team, this will develop collaboration between students and will facilitate their acquisition of useful social skills. All these teaching and learning methods have the role of adapting the teaching process to the current requirements that undergo changes over time, so that we can continuously improve the quality of education as a whole.

Innovative pedagogical methods and practices that can be used to learn the knowledge within these modules are project-based learning. Thus, based on the solution of the projects based on the practical activities, the knowledge in the presented fields can be exemplified and transmitted. Another method is to reverse the traditional teaching method and present the students with the modules for prior study, then instead of the appropriate teaching, an interactive lesson with questions, answers, discussions and the solving of practical activities as a model. An adaptive and personalized learning method can be approached for the student, depending on their needs in order to obtain an aridic officiant and better learning results.

Flexibility and open learning methods can also be applied to these courses, adapting the teaching of the modules to the needs and individual rhythms of the students. Thus, the course modules are available on the online platform, free of charge, and students can be guided to choose those subjects that interest them and thus they can plan their learning activities taking into account their own interests and learning rhythms. The use of a diverse range of learning methods and styles is encouraged in accordance with the needs and preferences of the students. The continuous evaluation based on feedback helps to identify the needs of the students and provide support for the activities in which they are involved.

3. SESSION OF TRAINING

3.1 Session description

3.1.1 IOT Session Training.

The first training session was presented by **Prof. Harsha Ratnaweera** and referred to the Internet of Things in water sector. The structure of this training was composed of the specific topics from the developed course.

Figure 1 - Training Session – IoT

The presentation consisted of presenting a summary of the learning materials, the results expected after the learning stages, the structure of the learning materials, new methods and tools that help in the learning process, as well as tools used for student evaluation.

3.1.2 BigData Session Training.

The second training session was presented by **Dr. Christos Markides** from UCY and referred to the BigData Analytics module of the BigData course.

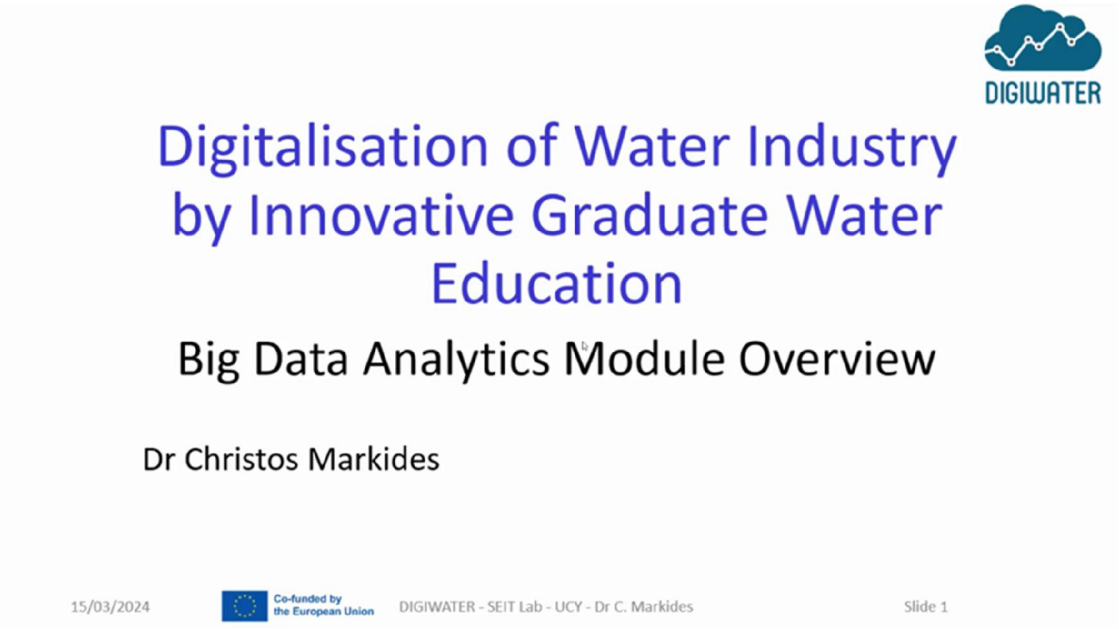

Figure 2 - Training Session – BigData Analytics

The presentation included the learning outcome, the structure of the learning materials, a lecture summary, participant support tools, and student assessment tools.

3.1.3 Participants

For the training session on IoT and BigData, 22 people joined the online session (Table 1). In addition to this, a group of 14 students from UGAL and NMBU attended the session in a classroom. Figure 3 shows a picture of the meeting.

Table 1 Participants in the open education session on IoT

Christos Markides	**UCY**	**Martin Oldenburg**	**THOWL**
Rashs Hassan	NMBU	**Bogdan Marcovici**	SMARTECH
Harsha Ratnaweera	NMBU	**Daniel Plath**	STEB
Laurentiu Luca	SMARTECH	**Marian Barbu**	UGAL
Elena Nikolaou	IACO	**Recep Kaya**	ITU
Milan Gocic	NMBU	**Thomas Fotiadis**	UCY
Alexandros Yeratziotis	UCY	**Ionut Enatoiu**	SMARTECH
Marios Mouskoundis	IACO	**Notetaker Alexis**	
Daan Buekenhout	KU Leuven	**Lucian Popa**	SMARTECH
Marian Craciun	UGAL	**Marios Kyprianou**	UCY
		Mehmet Lasaloglu	ITU

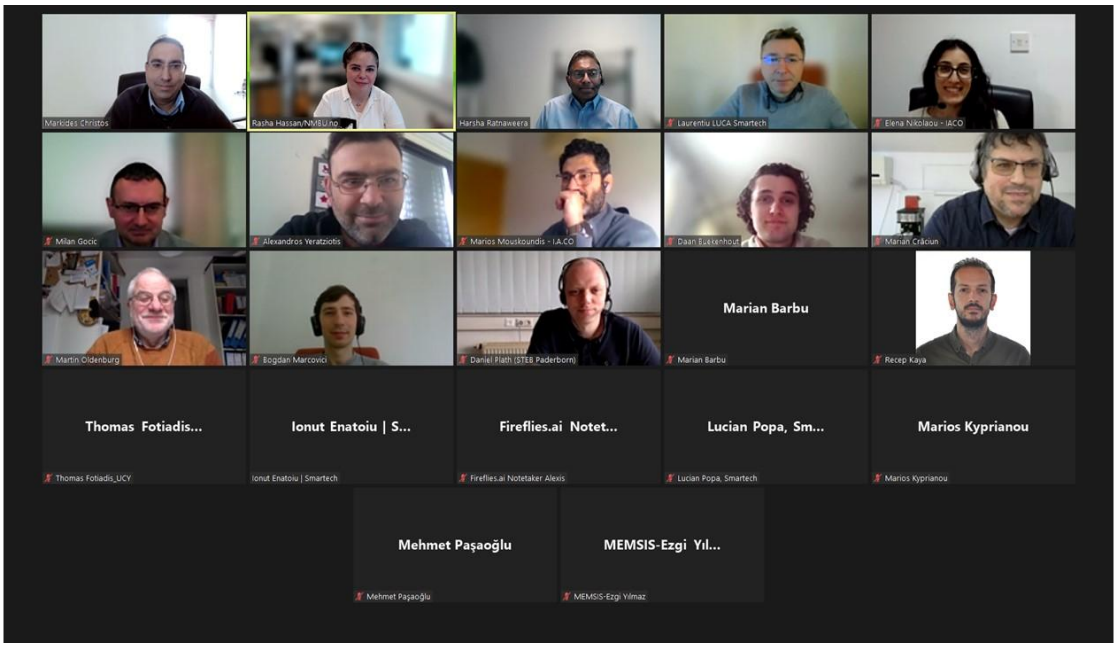

Figure 3 Picture of the open education session on IoT

3.2 Feedback

The feedback obtained during the training of trainers and trainers at universities and partners, either through the interactive discussion or the evaluation questionnaire, is briefly summarized in this section. The statements in this section are a synthesis of the feedback received.

In addition to feedback specific to individual modules, general observations were also made throughout the session.

4. Conclusion

In these sessions for the training of trainers and for the training at universities and companies, the training materials formed from the courses developed for the two important topics in the water industry, namely IOT and Big Data, were used.

The presentations of the two courses had two important elements, namely their content and the expected results after going through these learning materials.

For the teaching of these courses to students, it was intended to use learning methods based on technology, these courses being available on an online platform, a fact that facilitates active learning processes. Personalized learning methods and teamwork can be used.

The innovative pedagogical approaches in these courses are project-based learning methods. Access to the developed courses is free so that this pedagogical approach adapts to the preferences and rhythm of the students.

The objectives of improving student results and the quality of education, its accessibility, interactivity and flexibility were continuously pursued through the integration of open educational resources and IT tools and computing techniques in this learning process.