A Practitioner's Guide to Digital

Realizing the potential of digital collaboration tools and serious games

Gamified Workshops for Water

in educating students on pressing topics in water-related higher education, supporting building digital readiness, and building resilience against crisis and shocks

Education

SMARTEN

European Commission

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Introduction. On the road to digital education readiness

Background & Motivation

The world has been witnessing numerous crises and shocks on different dimensions which have a profound impact on societies (Ref). The COVID-19 pandemic as a recent crisis has illustrated starkly the need for preparation, improved capacity and resources (Ref). As a consequence of the scenario of COVID-19, the European Commission has prioritized recovery and building resilience as a way to move forward for effective strategic crisis management[1]. Among these efforts is boosting digital transformation and building digital readiness[2]. Promoting the digital sphere could cover specific needs and issues of particular importance that emerge for the resilience of critical infrastructures in EU countries.

UNESCO estimates that over 1.5 billion students in 165 countries are out of school due to the COVID-19 pandemic[3]. The pandemic has forced the global academic community to explore new ways of teaching and learning, including distance and online education. This has proven challenging for both students and educators, who must deal with the emotional, physical, and economic difficulties posed by the illness while doing their part to help curb the spread of the virus. The future is uncertain for everyone, particularly for millions of students scheduled to graduate this year who will face a world crippled economically by the pandemic.

Realizing these facts, the European higher education was among the critical sectors which received additional funding to respond to the pandemic. The Call 2020 Round 1 KA2 - Cooperation for innovation and the exchange of good practices was produced as a result of this funding. KA226 - Partnerships for Digital Education Readiness was one of the key actions of this call to overcome the lack/insufficiency of digital readiness across Europe which has caused serious difficulties for higher education institutions to provide high-quality online education. As a response to this call, SMARTEN (Serious gaMes for digitAl Readiness of waTer EducatioN) project was submitted and accepted.

SMARTEN Overview

SMARTEN (Serious gaMes for digitAl Readiness of waTer EducatioN) gathered four partners (NORGES MILJO-OG BIOVITENSKAPLIGE UNIVERSITET, H2OPeople, University of Thessaly, University of Nis) from four different European states (Norway, The Netherlands, Greece and Serbia) having complementary profiles allowing them to have the ideal competence-based mix to design and implement a truly impactful collaborative project. Jointly, they provided six digital gamified workshops on three water-related serious games, guidelines and assistance tools for facilitators, ICT tools for learning path and experience, instruments of augmented collaboration, a compendium of real-life case-studies for project-based learning, supporting teaching and training digital content, tools for the involvement of regional stakeholders in serious games, six universal eLearning modules

The main objective of SMARTEN was to support building digital readiness in water-related higher education and lifelong learning as well as mitigate impacts of the

COVID-19 crisis on the educational activities. The project focused on innovative practices based on serious games in education, addressing the water subject in line with the European goals on environment and climate. It has also promoted internationalisation as a key priority for building responsiveness, adaptability, and flexibility of education against external disruptors.

The project was designed towards the needs and for the benefit of students of water-related programs, young water professionals, water educators in academia and industry, water society and European community at large.

Four intellectual outputs were produced by SMARTEN and published on its website:

- IO1: Digital Gamified Workshops.
- IO2: Augmented Collaboration Toolkit.
- IO3: Case studies for research-based learning with serious games.
- IO4: eLearning modules for serious games.

As a result of IO1, this guideline on implementing digital gamified workshops on six different topics related to water and wastewater management was produced aiming to benchmark and disseminate these good practices. We designed this guideline aiming to be used by eight TARGET GROUPS. It supports water educators and trainers in the development of new digital active teaching and learning form of online workshops with serious games. It tackles the problem of "Zoom fatigue" experienced by students and trainees. It provides a digital tool for engagement with other stakeholders based on collaborative work – practitioners, experts, specialists, professionals, decision-makers, researchers.

Why to read this guideline

We aimed when designing this guideline to create a tool that can:

- INNOVATE by implementing tools for virtual collaboration and high-quality decision-making in teams of learners, teachers and stakeholders, regardless of physical presence at workshops. This guideline focuses on water curricula modernisation with digital active learning by developing an innovative methodological framework for online workshops that combines water related serious games with group facilitation techniques. It promotes digital workshops as flexible learning pathways that develop creativity and innovation skills through digital peer learning. It also facilitate the integration of innovative serious games available as open education resource from other educational, research and innovation European projects into universities' curricula and training programs of LLL bringing connection with industry and social innovation.
- CREATE a deep IMPACT on the way educators teach and train in organisations. This guideline supports digital transformation by introducing participative teaching and learning in an active form of online workshops, engaging not only teachers and learners but also a wide range of stakeholders such as practitioners, experts, specialists, decision-makers and researchers. It also supports the development of transversal and digital skills as well as

management and leadership skills engaging learners and trainees into facilitation. Conducting such workshops between several organisations has supported inter-institutional cooperation. Focusing on real-life problems from North and Southeast Europe in serious games could help to increase inter-regional cooperation. All the serious games used here aim to create synergies between policy and practice by addressing relevant real-life case studies together with measurable policy interventions.

- Be highly TRANSFERABLE both technically between organisations interested to implement it and between other disciplines, teaching and training areas. Transferability to different organisations, teachers and trainers will be assured by creating all tangible outputs (e.g., guidelines) in digital format and making it available online through the project website (https://smartenproject.eu/), Water Europe website, Erasmus+ project results platform and websites of other projects of the partner organisations. The workshop brainstorming templates created in the online tool GroupMap will be easy to transfer between GroupMap accounts or to download and share as PDF files. The methodology will be specified generically so that it can be transferred to other disciplines, subject areas and learning and training activities.

Chapter 1. The needs for digital workshops and serious games

According to UNESCO[3], COVID-19 led to the highest ever seen **learning loss** – loss of knowledge or skills and/or deceleration of or interruption to academic progress, most commonly due to extended gaps or discontinuities in a student's education. "The state of the global education crisis" report shows that on top of forgetting and forgone learning, additional learning losses could accumulate even after students return to universities (Figure 1).
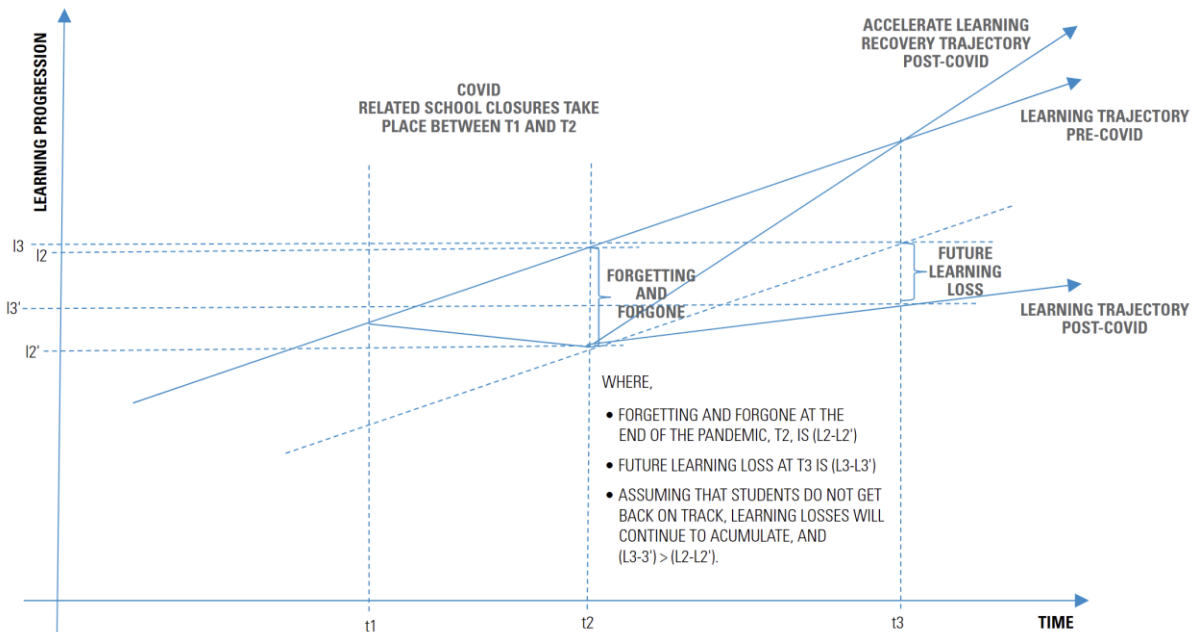

Figure 1 – Learning trajectories pre- and post-COVID, showing implications of current learning losses on future learning [3]

The pandemic revealed how digital technologies make the world more deeply interconnected and interdependent than ever before, but also more divided[3]. It has accentuated the digital skills gap that already existed, and new inequalities are emerging as many people do not have the required level of digital skills or are in workplaces or schools lagging in digitalization. For example, autonomous learners may have coped well with working remotely, while students with learning difficulties may have been overwhelmed. A reflection is needed on how student services, counselling, and peer support can be provided remotely.

On the eve of the crisis, most institutions (80%+) indicated that they had online repositories for educational materials in place, a centre or unit that supports teachers on digitally enhanced learning and teaching, as well as digital skills training[4]. These capacities may not have been sufficient for the suddenly increased demand, and not all staff and students were familiar with them.

Internationalization was hit first. An early EAIE survey report showed that almost two-thirds of institutions saw their outgoing student mobility impacted. For short-term mobility, such as Erasmus+, some institutions have already cancelled short-term mobility in the next semester or even academic year, and others are envisioning hybrid

or blended approaches. So far, neither virtual mobilities nor the virtual international classroom, while technically feasible, have become common practice in higher education and training.

Zoom, Teams, Webex, Google Meet, and Skype became the most popular platforms being used by educators. While these make it easy and efficient to conduct live video teaching from home, an increasing number of educators and their students express what they term 'Zoom fatigue'.

There are three main reasons of Zoom fatigue that need to be tackled in the new curriculum: (i) unfocused attention due to distractions in the background; (ii) physical tiredness from passively watching video lectures; (iii) numerous video meetings making study schedule hectic and monotonous[5]. Thus, if we want to keep our mental health and prevent burn out and fatigue, we must start using strategies to make our virtual courses more energizing and easier to digest.

One of the ways to address zoom fatigue is to invest in the enabling environment to unlock digital learning for all students [3]. When carefully planned and adequately resourced, digital and hybrid learning has the potential to support learning continuity in the face of future school closures. Therefore, we must systematically invest in strengthening the enabling environment that advances digital learning for all students, especially the most marginalized.

> **What is the psychological explanation of Zoom fatigue?**
>
> A core psychological component of fatigue is a rewards-costs trade-off that happens in our minds unconsciously. Basically, at every level of behaviour, a trade-off is made between the likely rewards versus costs of engaging in a certain activity. Even minor decisions, such as pressing the "Delete" versus "Backspace" button to erase a typed word, are made on the basis of these unconscious estimates to maximize reward (ex, time) over cost (ex, effort). The link between this reward assessment and fatigue then comes here: activation of the dopaminergic pathways in brain structures associated with reward (e.g., ventral striatum, anterior cingulate cortex (ACC), amygdala) increases subjective alertness, energy, and motivation – the opposite of fatigue.
>
> *Source: 5*

1.2 Serious games

Game is an unsolicited mental or physical activity, therefore self-engaging and motivating by itself. It is an activity with no aim other than leisure or fun, framed with rules, which offers a chance to win or lose, and requires a variable proportion of skill, dexterity, and hazard[6]. Games offer an escape from ordinary life, i.e. are characterized by a degree of fiction, and are most often framed in time and space[7]. They are systems where players engage in artificial conflicts defined by rules, resulting in quantifiable outcome[8].

Emotional and motivational learning aspects can be addressed by gaming using serious games or gamification[6]. Education is a good example of using game design

elements in non-game context[9]. In such a context, "serious game" sounds like a paradox because "serious" can't induces a change be "with no aim, but fun".

> **Serious games** are games with an explicit and carefully thought-out educational purpose and not intended to be played primarily for amusement".

Serious games can be of any type: card and board games, video, or simulation games. Serious games facilitate (1) learners' engagement through intrinsic game motivational features, (2) the potential for interactive visualization, and (3) the ability to both create social learning and develop decision-making skills[6]. Serious games make the participant notice the task and raise his/her interest in keeping attention on learning. They also bring context-specific information and in view of a clearly defined goal which makes sense to the learner. However, serious games are rarely used in water-related education and share of active digital teaching in partner organizations is 5-10%. Thus, we identified serious games as a promising tool for active digital teaching and learning.

Learning by serious games can be clarified by Kolb's experiential learning cycle, which views learning as a process, which includes four essential phases: Active experimentation and specific experience, Direct experience, Reflexion, and Assessment[10]. Active experimentation and testing lead to direct experience[11]. Direct experience allows for reflection on different aspects of the experienced situation both at an individual as well as at a group level. Based upon this reflection, an assessment as well as a definition of the consequences and potential generalization possibilities leads to the awareness of new actions. This experiential learning approach requires a free, self directed and self organized learning process. Effective engineering education needs a learning-by-doing approach characterized by moving from passive perception to active experience. However, there are not enough real life situations that can be used for education or training, since in many real life situations the occurrence of errors or mistakes – which are natural in learning situations – are not acceptable. Simulation games using advanced information and communication technology can be used as a substitute in order to meet this need for active experience[12].

The diversity of serious games in the water sector can be represented in two dimensions (Figure 2) of the technology used (X-axis) and the degree of verisimilitude (Y-axis).

The review of 43 serious games in water sector[6] uncovered a span of all purposes:

- Broadcast a message such as household water consumption, integrated water resources management, or flood risks

- Facilitate exchange of information between targeted players

- Train players reproducing a real-world simulation with accurate reality

- Reflect a diversity of water issues in broad sense and at various scales
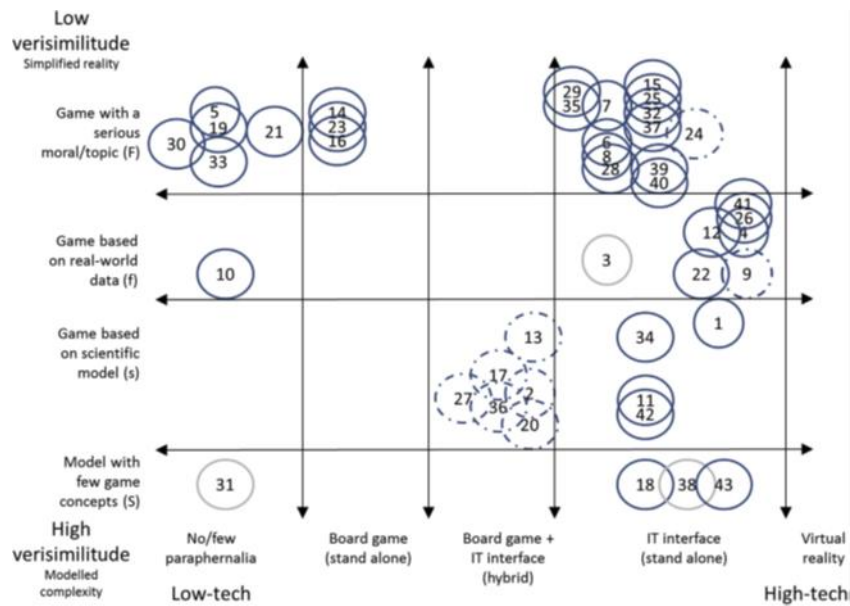
Figure 2 – Variety of serious games in the water sector [6]

Gameplay loop (Figure 3) is the cornerstone of gamification. A win/loss state in serious games makes the player analyse the choice. A loss state may create cognitive dissonance (or conflict) within an individual, and can hereby enhance learning if the person aims at reducing this inner conflict (identifying the reasons, and adapting)[13]. Reflecting based on an experience is a learning process known in many learning theories, e.g. Kolb's experiential learning cycle [14], or Argyris' single- and double-loop learning [15]. In game-based learning, when taking an action, the player has some expectations concerning how the model will work. Their action induces a change in the game environment which leads to a reward or penalization. Then, the player can evaluate her prior expectation by confirming it and continuing to play, or by formulating a different expectation to be tested in the trial of this loop. The game offers a safe environment to learn from trial and error.
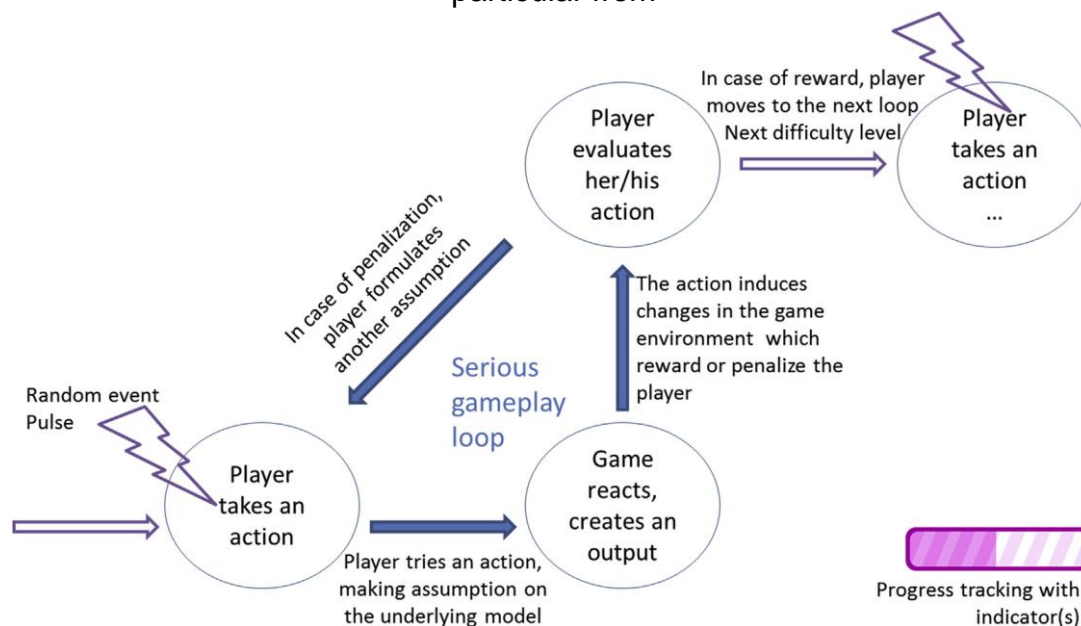
particular from

Figure 3 – Serious gameplay loop[16].

Serious games thus not only offer a safe trial and error environment, but they are also engaging, motivating and attractive. Motivation by serious games is based on the Self-Determination Theory that a game can enhance the internalization of extrinsic motivation by providing a feeling of competency, autonomy and relatedness to the players, and, when relevant, by stressing the intrinsic goals of the player[17]. Serious games also trigger collaboration through role play, and end with a debriefing on what happened, and what was learnt.

Thus, serious games show a promising match between the aims of serious games and the challenges that water-related higher education is facing during the disruption of COVID-19 pandemic (Table 1). Methods used in serious games limit the cognitive load, avoid biases, and allow for experimentation and learning. These include e.g., learning, in particular from feedback, processing and retrieving memorized information, and motivation.

Table 1 – Fitness of games to the different steps of an educational process[10]

Educational process' step	Fitness of games
Initial motivation.	Games look very useful for raising awareness and interest of a student about a new topic
Theory	Here the role of the teacher and of tools like books look quite effective and efficient, especially to support abstraction
Practice	Games look very useful for practicing learned contents. Games should be of various levels, allowing different degrees of freedom according to the student expertise. Supervision of the teacher is highly recommended in order to avoid misconceptions and loss of coordinates that could easily arise in a complex simulation environment
Verification	Games could be useful to verify some aspects of knowledge/skill acquisition, but attention should be paid to avoid over-fitting on the game mechanics. In general, use of digital games is particularly suited for tracking the user and understanding his performance under some measurable dimensions, through learning analytics

1.3 Digital gamified workshops

"Zoom fatigue" has emerged as a new term being applied to the sense of boredom and tiredness learners feel from attending numerous online sessions throughout the day. Educational researchers have already studied Zoom fatigue and suggested several measures such as balancing synchronous and asynchronous activities, frequent short brakes between tasks, assigning roles in discussions, involving students into leading online activities, making space for fun with gamification and using break-out rooms frequently. Therefore, educators need to reimagine their teaching approach towards forms of collaborative active learning and have the proper tools to make it memorable and rewarding for both students and teachers.

Professional group facilitation is the best approach to developing an effective collaborative culture between teachers, learners and other stakeholders, and having more productive workshops is a way to accomplish that higher goal. However, many European education and training organizations do not have the resources or just the willingness to hire a facilitator in-house; therefore, there is a need to support those in achieving effective workshop results with the right kind of non-human assistance.

Our preliminary experience with serious games for training shows that most trainees do a poor job of correctly identifying problems that need to be solved in the game. They rather follow the explorative path applying different interventions (policy cards in the game) and looking at the outcomes without noticing and reflecting on the causes and effects – trial and error method. However, the true learning goal of such serious games is to induce optimization mindset and stimulate to solve inverse problems empirically. Proper learning path and experience can be created with **digital workshops** that need strategic use of ICT and virtual collaboration tool (GroupMap) together with three serious games (SIM4NEXUS, SIMBETHEL and eCity).

1.4 Augmented collaboration tools

The COVID-19 accelerated the need for augmented collaboration tools within the water sector and especially in water education. The needs in the sector the coming decades are high with current and future transformations - such as climate change, digitalization – for a changing collaboration, new and different skills in personnel. To be able to create an impact and apply the needed transformation, the traditional water sector needs to learn to adapt and apply augmented collaboration tools.

Within the augmented collaboration tools, serious games play a key role. They are not only the games itself, but the games will be used within the toolkit. The toolkit facilitates the games to support collaboration throughout the different target groups and work towards a joint narrative (storytelling) and other needed soft skills to create true collaboration. A joint skills approach and storytelling will improve collaboration through serious games from a different type of learners and supports the search for common and innovative solutions.

We need to develop ourselves from Basic Collaboration – Advanced Collaboration to Augmented Collaborative. We cannot do it by ourselves and need to be supported digitally. It supports the spontaneity needed for creativity and has its benefits of the planned and organized process, resulting in a fully engaged and participative process. The technological tools offer a collaborative working environment and the conditions for people to be productive and learn in the new space. The augmented toolkit should not only focus on technical digital innovations, but it will also focus on the process.

Chapter 2. The concept and methodology behind this guideline

2.1 The methodology used in developing this guideline within SMARTEN consortium

The process behind conducting the digital gamified workshops as well as producing this document required inputs from all four partners. Figure (4) shows the step-by-step process followed by SMARTEN consortium to implement these workshops.
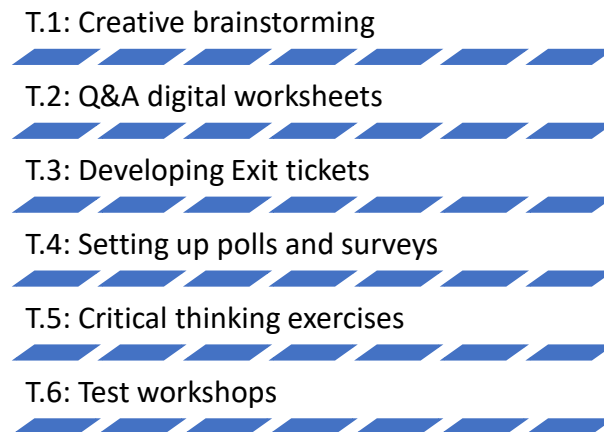
T.1: Creative brainstorming

T.2: Q&A digital worksheets

T.3: Developing Exit tickets

T.4: Setting up polls and surveys

T.5: Critical thinking exercises

T.6: Test workshops

Figure 4 – The followed process in implement the digital gamified workshops.

In order to develop these 6 digital workshop Figure (5), two serious games (SIM4Nexus and Adaptive Planning) and three digital collaboration tools (GroupMap, Miro, Zoom break-out rooms) were used Figure (6).

Each workshop aimed to highlight the broader topic of the NEXUS: Water, Climate, Land, Energy, Ecosystems and Food.

The reference group in the implementation process was NMBU students and international students of NMBU summer school (7 countries – 14 universities). Figure (6) shows the steps that were followed in each workshop.
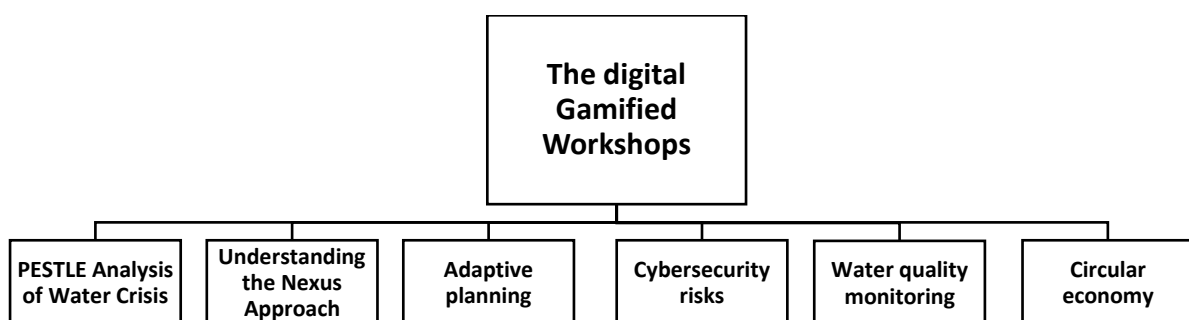
The digital Gamified Workshops

| PESTLE Analysis of Water Crisis | Understanding the Nexus Approach | Adaptive planning | Cybersecurity risks | Water quality monitoring | Circular economy |

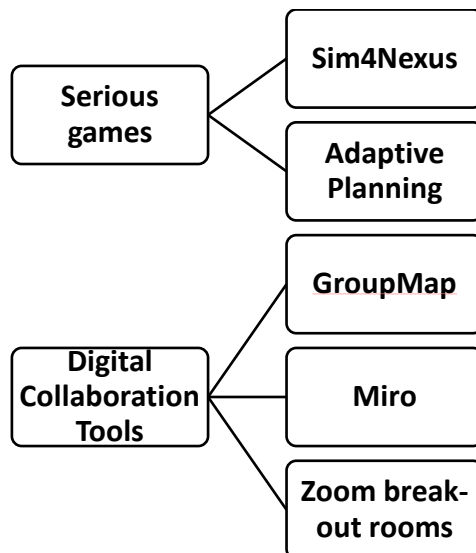Figure 5 – The topics of the digital gamified workshops.

Figure 6 – The tools used in the workshops.

2.2 The methodological framework for the workshops' implementation

The methodological framework for the implementation of the online workshops with serious games and the selected digital tools was based on the Learning Management System. The effective use of Learning Management System (LMS) is essential to support online learning and implementation of digital learning tools such as serious games.

The previous practice of using LMS as a file storage needs to be changed following the principles of interactive structure:

- Showing students a summary of the workshop with learning goals.
- Implementing the schedule that corresponds with the syllabus and objectives of each workshop.
- Structuring tasks following the workshop structure.
- Using the augmented digital collaboration to develop the discussion and facilitate collaboration within the students' groups.
- Engaging with students in group discussions using the selected digital tools.
- Organising file storage using Canvas following the syllabus and the workshop schedule.

As a result, the following steps were followed in each workshop:

1. Providing input on the topic of the workshop: This step was performed by giving related lectures by key-note speakers.
2. Assigning specific tasks: This form of activities was given to students to achieve the objectives of the workshop after dividing them into groups.
3. Debriefing: After doing the tasks, the students were asked to give a five-minutes presentation.

Chapter 3. Step by step guideline

How to read this chapter

We followed a specific structure to report on the digital gamified workshops for water education conducted by SMARTEN. This structure can be replicated for any workshop under any topic.

Here are the steps:

- **The title**: We introduced each workshop by its name.
- **The input**: This part introduces the names of speakers, the group work, briefly the topic and supportive materials.
- **The task**: This part describes the activity which was asked by the lecturer to students to engage them and promote the discussion and collaboration among them.
- **The augmented collaboration tool:** This section shows the used digital tools and in which capacity and form.
- **Debriefing:** This part describes how the debriefing process took place.

In the following, all the information about the digital gamified workshops is presented.

3.1 Workshop (1): PESTLE Analysis of Water Crisis

3.1.1 Input

The aim of this workshop was to address the global water crisis, explore the related challenges and identify the related factors using PESTLE analysis.

PESTLE is a strategic analytical tool used to assess external factors affecting the topic under study[18]. This framework stands for the following factors, Figure (6):

- **P**olitical factors include political stability, corruption, regulations, government policies, leadership, and change.
- **E**conomic factors include current and projected economic growth, job growth and unemployment; inflation, labour costs; impact of globalization, likely changes in the economic environment.
- **S**ocial factors include demographics (age, gender, race, family size); stakeholders' attitudes, opinions, and behaviour patterns, population growth rate and employment patterns, socio-cultural changes, ethnic and religious trends, living standards.
- **T**echnological factors include the current and future technologies and resources, copyright and patterns, and production and distribution.
- **L**egal factors include regulations, health and safety, equal opportunities, consumer rights and laws, anti-trust laws.
- **E**nvironmental include availability of inputs, pollution targets, doing business in an ethical and sustainable way, corporate social responsibility, water footprint targets.

The first stage of PESTLE started with brainstorming and identifying generally the issues that influence the global water crises then to classify them using the six factors.

The input of this workshop was Flow: For the love of water .

The group work in this workshop was organized through the structure shown in Figure (7). The process started after introducing the task by forming the groups. The work within each group started with organizing the members by assigning roles including timekeeper, notes taker, slides maker; and lasted for one hour. Following this step came the brainstorming about the global water crisis using the PESTLE framework. Finally, each group presented a five-minute presentation.

Understanding Water Crisis **Factors**
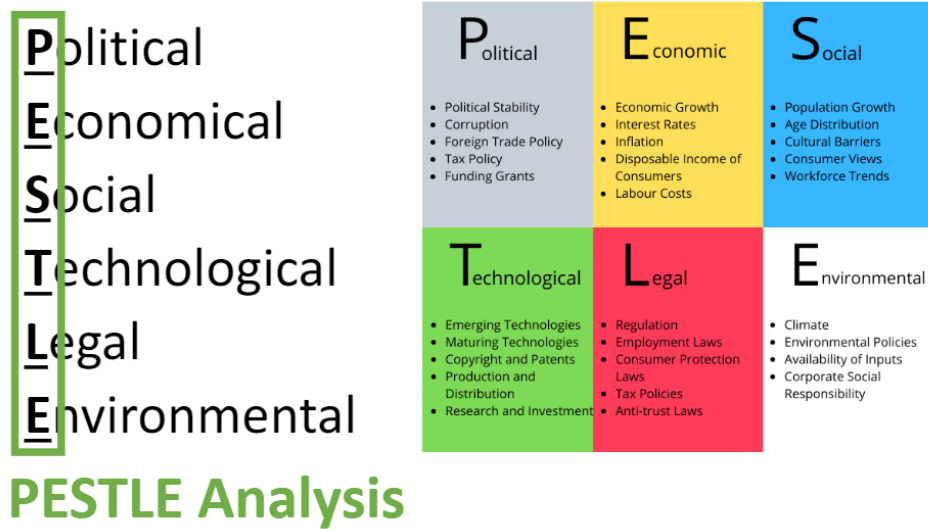

PESTLE Analysis
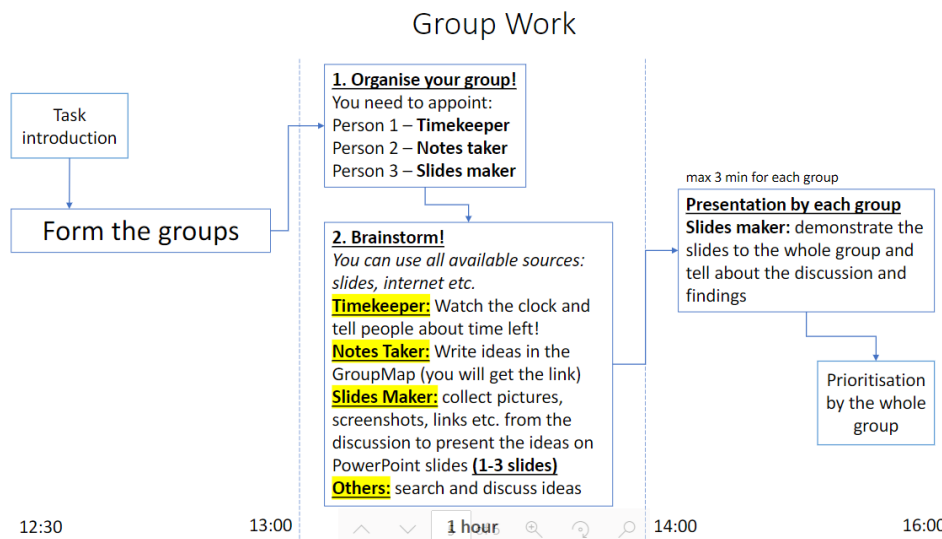
Figure 6 – PESTLE Analysis.

Figure 7 – The group work.

3.1.2 Task

The aims was to identify the Political, Economic, Social, Technological, Legal and Environmental factors that impact the water crisis.

3.1.3 The augmented collaboration tools

Both GroupMap and Zoom break-out rooms were used in this workshop. The brainstorming process took place in GroupMap, Figure (7). The students were able to write their ideas as shown in Figure (8).

Figure 7 – PESTLE in GroupMap.
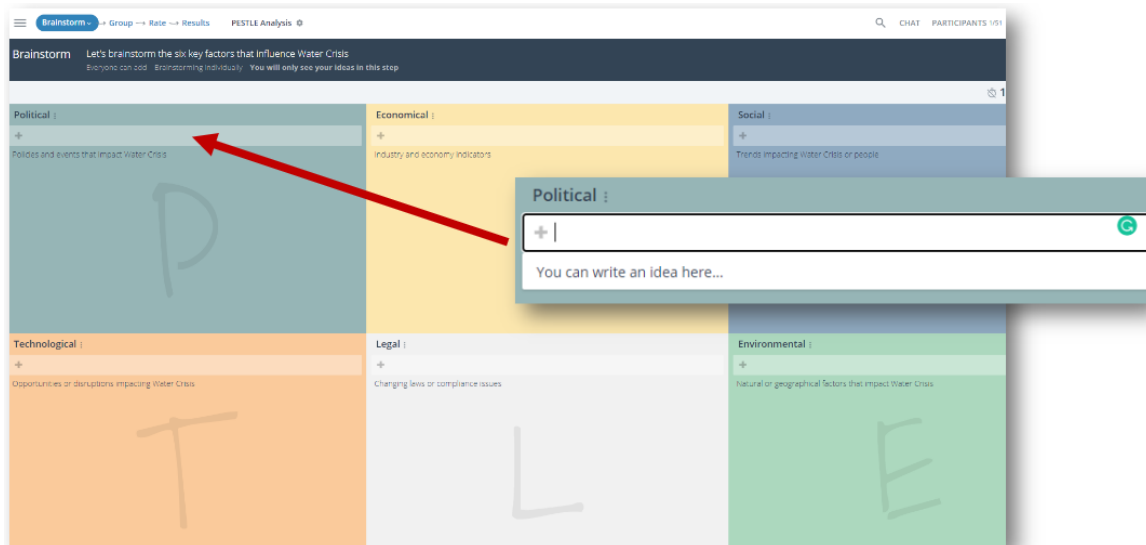
Figure 8 – Brainstorming in GroupMap.

3.1.4 Debriefing

The allotted time for each group was between 3-5 minutes. Figure (9) presents the different ideas introduced by students.

Debriefing
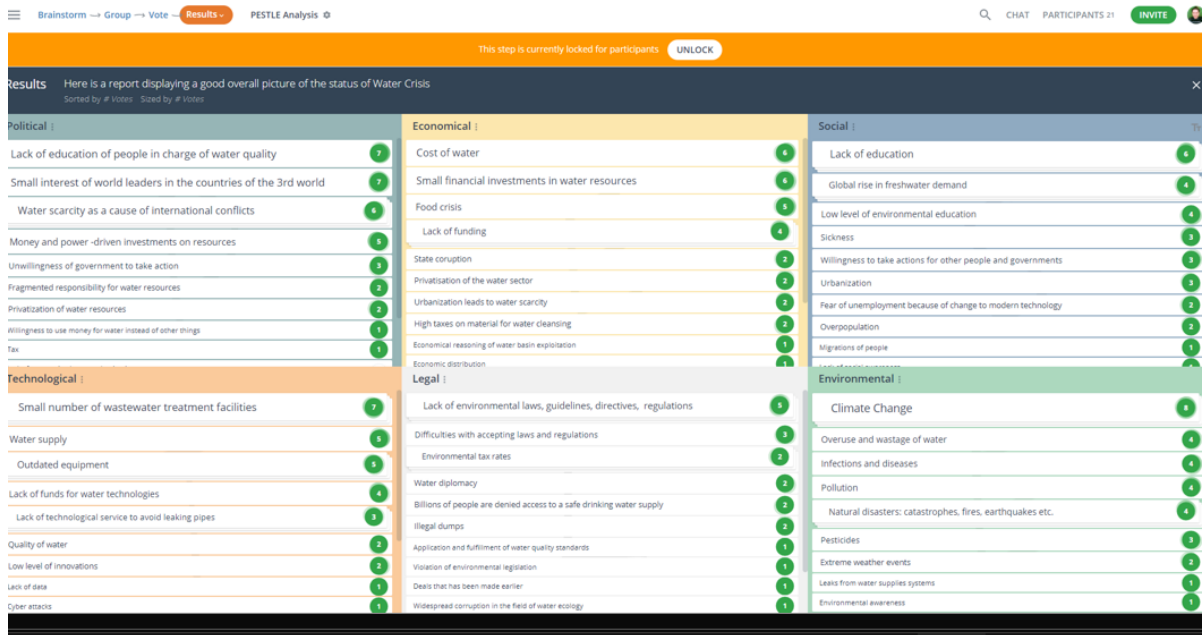
Figure 9 – The debriefing of the water crisis.

3.2 Workshop (2): Understanding the Nexus of Water-Land-Food-Energy-Climate Approach

3.2.1 Input

The unprecedented increase in global population and other challenges including climate change play roles in magnifying or reducing the growing stresses on the vital resources of water, energy and food (WEF). Here comes the role of the Nexus approach to point out that all the WEF systems are highly interconnected: food production requires both water and energy; pumping, treating, and transporting water requires energy; energy production requires water[19,20]. Decisionmaker often develop the national strategies for governing the management of one system independently of the other two systems, thus failing to consider the interconnections between the three[19]. This often results in conflicting strategies and increased competition for the same resources. The aim of this workshop was to suggest the best policy card in the resources' management using SIM4NEXUS serious game, Figure (10).
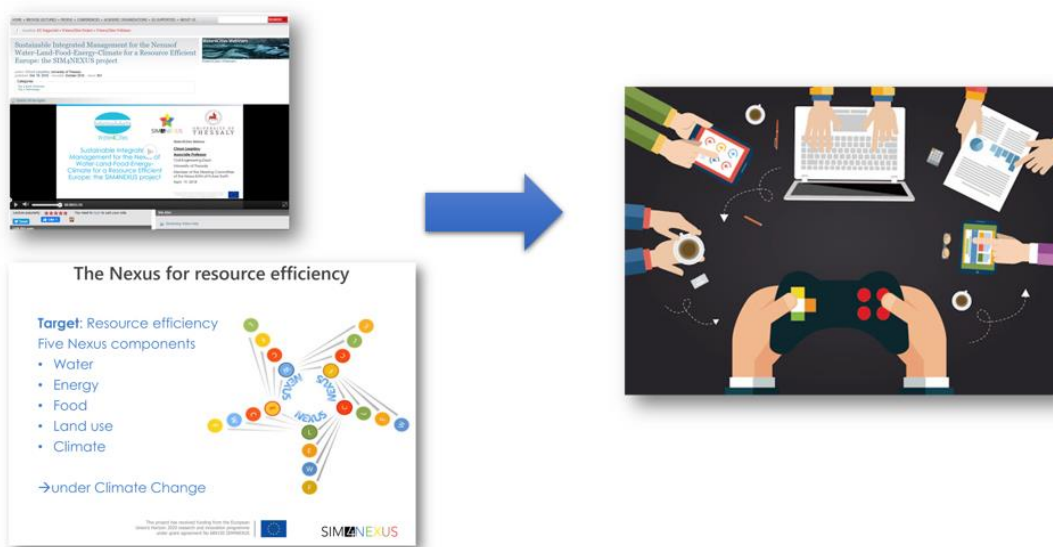
Figure 10 – Understanding the Nexus approach.

Two lectures were used as an input for this workshop:

- Integrated water resources management & Water quality which is a part of Dr. Hani Sewilam course on edx platform.
- Sustainable integrated management for the Nexus of Water-Land-Food-Energy-Climate for a resource efficient Europe: The SIM4NEXUS project by Prof. Chrysi Laspidou

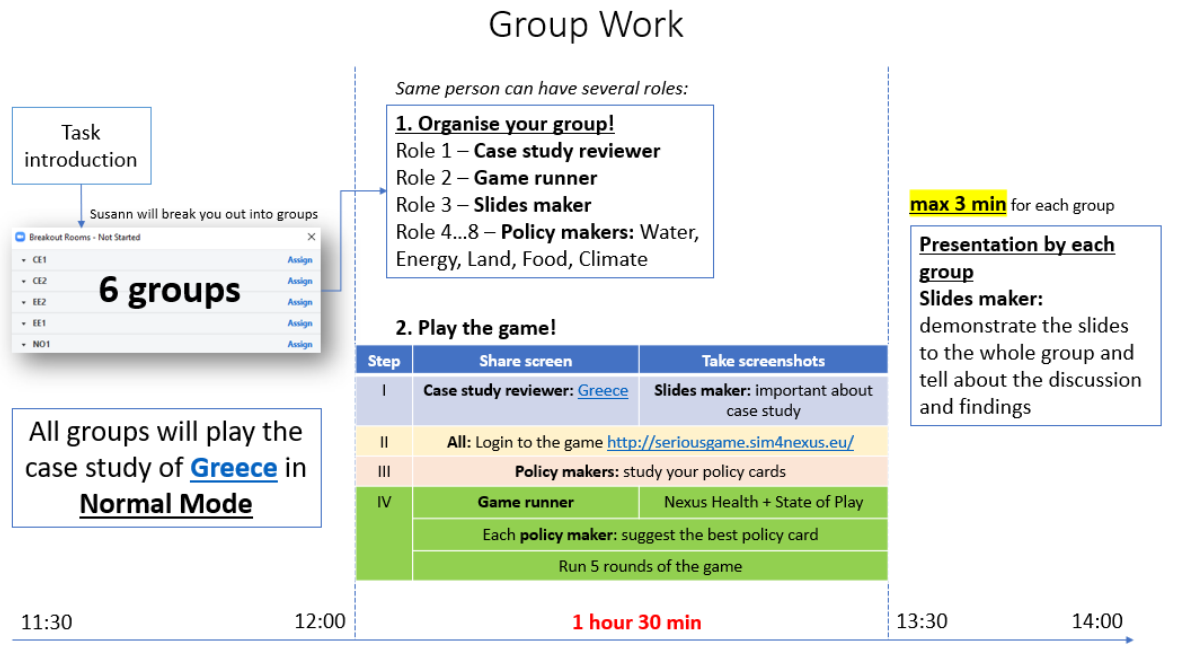The group work in this workshop was organized through the structure shown in Figure (10).

Figure 11 – The group work of this workshop.

3.2.2 Task
The task was to play the SIM4NEXUS collectively for each group for five rounds.

3.2.3 The augmented collaboration tools
To carry out this workshop, SIM4NEXUS, and Zoom break-out rooms were used. "The SIM4NEXUS serious game is a computer game that aids **learning about the Nexus** by helping users to understand and explore the interactions between water, energy, land and food resources management under a climate change context, divides the problem into manageable interventions, and allows participants to learn by doing. The ultimate goal of game development is to create a fun and interactive capacity-building tool to be used in research, educational settings and management. The SIM4NEXUS Serious Game enables players to implement policies in a gameplay environment and explore how policies impact on different Nexus components. Summary information is given about policy actions, assigned costs and potential benefits; this facilitates scorekeeping according to both financial and social capital metrics."

3.2.4 Debriefing
The allotted time for each group presentation was 5 min. Figure (12) shows an example of the debriefing of policy cards in each round. The resulting card from each round is considered a summary information which points out the policy actions, assigned costs and potential benefits; this gives the opportunity to measure the progress and compare the different results produced by each action.
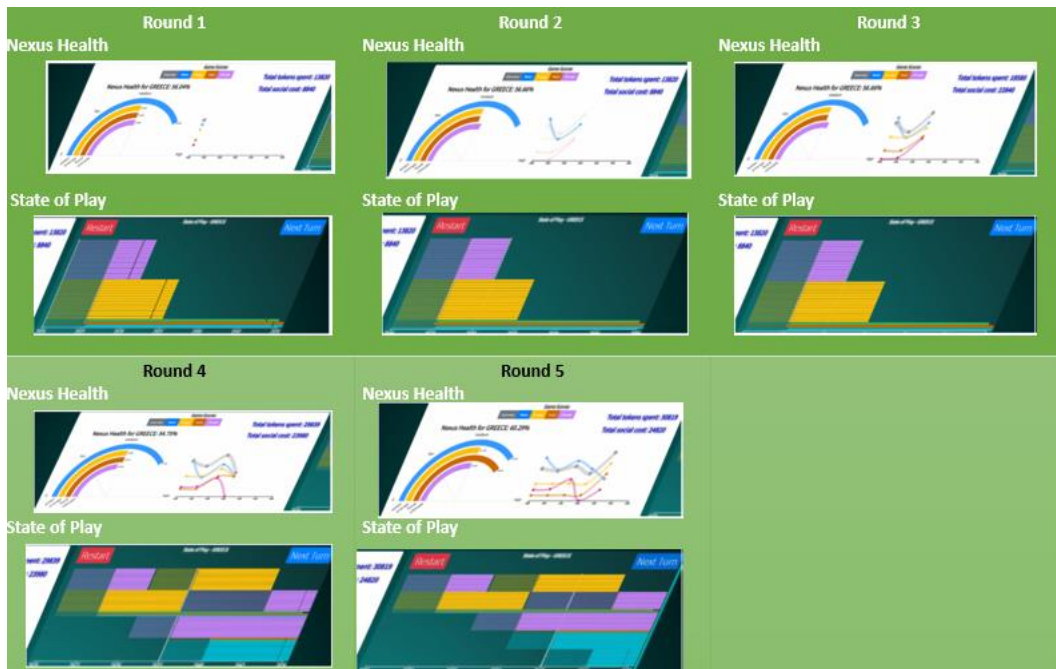
Figure 12 – The debriefing step.

3.3 Workshop (3): Adaptive planning

3.3.1 Input

Two components were used as input for this workshop:

- Planning of water utilities for the future.
- Videos from TU Delft.

The key messages from these materials are:

- **Infrastructure is vulnerable** to unexpected or difficult-to-predict events.
- Deep analysis of uncertainties is needed to **anticipate change** and to **design adaptation pathways**.
- Experts and policy-makers need to develop **long-term policies** that can anticipate these uncertain changes rather than merely react to the undesired events they bring about
- Professionals in these fields need theory, innovative tools and methods to cope with uncertainties and enable them to design **adaptive plans.**

The group work in this workshop was organized through the structure shown in Figure (13). The process had two rounds which included playing the game individually then moving to a group. The individual round started with launching the game and getting familiar with it by playing it several times; and lasted for 45 minutes. Afterwards, the students formed numerous groups to join them where they discussed four key questions; and this round lasted for one hour:

- What did you experience?
- What motivated your decision?
- Did your points of view change?
- How can we improve water management planning?

These questions aimed to stir the discussion on this particular issue.

3.3.2 Task

The task was to Play Adaptive Planning game (AP).

3.3.3 The augmented collaboration tools

To carry out this workshop, AP game and Zoom break-out rooms were used.

3.3.4 Debriefing

The allotted time for each group presentation was 5 min. The overall debriefing by the groups is shown in Figure (14).

The group work

I. Launch the game https://delftxtools.tudelft.nl/apg-practice/
II. Read the explanation
III. Start and play the game individually (you can play several times)

IV. Once you are finished playing the game individually, **discuss in your group:**
1. What did you **experience**?
2. What **motivated** your decisions?
3. Did your **point of view** change?
4. How can we **improve** water management planning?
Important: Listen to every participant in the group

V. Make a presentation (slides) **summarising your findings in the group** about experience, motives, points of views and ways to improvement

VI. Presentations in the joint session (**3 minutes** per group)

Figure 13 – The groupwork.
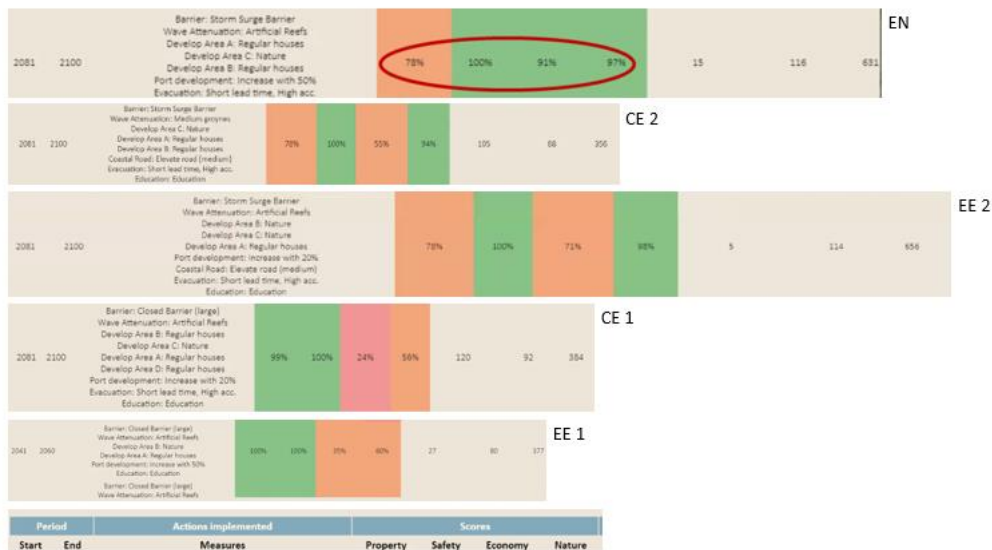
Figure 14 – The overall debriefing.

An example of the game steps is presented in Figure (15).

Figure 15 – AP steps.

The result of playing this game by a one group is shown in Figure (16).
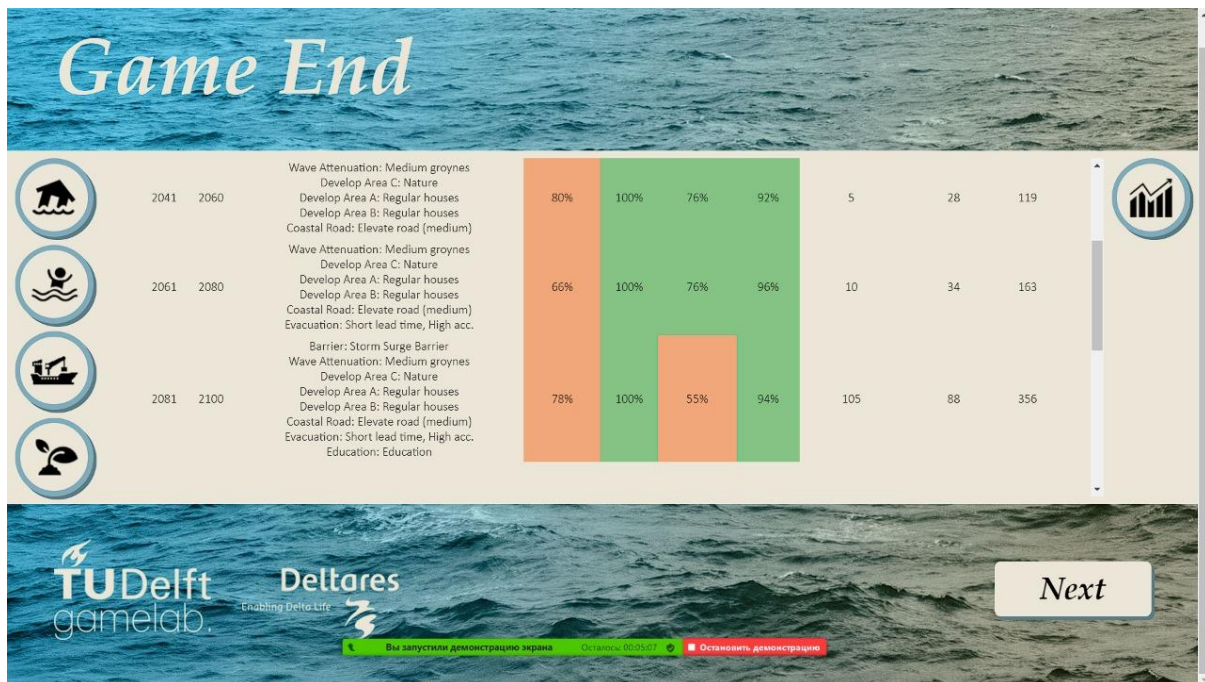
Figure 16 – The obtained results.

3.4 Workshop (4): Water quality monitoring

3.4.1 Input

The following two lectures were used as an input for this workshop:

- Modern analysis techniques for water pollutants by Agnieszka Cuprys, Zakhar Maletskyi. This lecture explored the following points:
    - Challenges in water pollution.
    - Sampling and sample preparation.
    - Mass spectrometry.
    - Separation techniques.
    - Spectroscopic techniques.
    - Other techniques – future trends.
- Water quality monitoring: Sampling and online monitoring by Harsha Ratnaweera. This lecture explored the following points:
    - Sampling-methods and error sources.
    - Status and need.
    - Online measurements and instruments.
    - Applications in surveillance and control.

3.4.2 Task

The task of this workshop was to design a water quality (WQ) monitoring plan by exploring two options:

- The conventional water treatment process.
- The chemical-biological treatment.

3.4.3 The augmented collaboration tools

To carry out this workshop, Miro and Zoom break-out rooms were used.

3.4.3 Debriefing

The allotted time for each group presentation was 5 min. Figure (17) shows the overall work presented by the students.
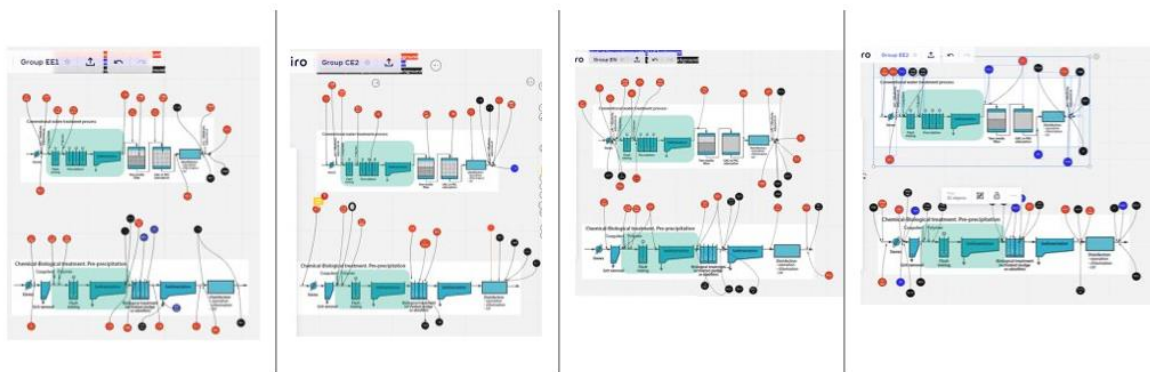
Figure 17 – The debriefing results.

3.5 Workshop (5): Cybersecurity risks

3.5.1 Input

The aim of the workshop was to identify and understand risks arising from digitalization in the water sector using GroupMap. Two components were used as input for this workshop:

- A lecture "Digitalization in the water sector"
- Video: [Hacking the Water Supply: Florida Cyber-Attack Explained](#)

3.5.2 Task

The participants were asked to do the following steps according to the selected process in GroupMap, Figure (18):

- The participants were asked to try and identify as many risks as they can and position them on the risk landscape using GroupMap.
- All participants were instructed to vote for risks that they think should be our top priority.
- The participants were asked to suggest mitigating actions for each risk, specifying what action they suggest, who should perform said action and when.

3.5.3 The augmented collaboration tools

To carry out this workshop, GroupMap and Zoom break-out rooms were used.
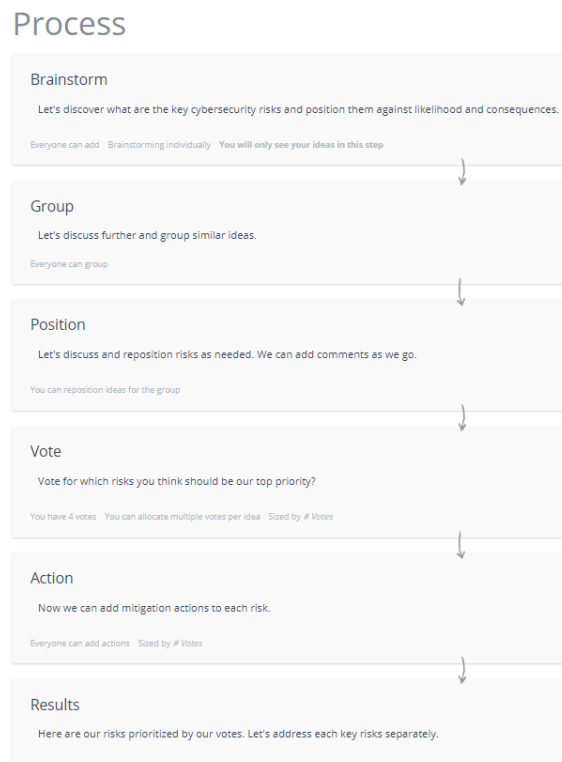
Figure 18 – The executed steps in GroupMap.

3.5.4 GroupMap results

Brainstorm
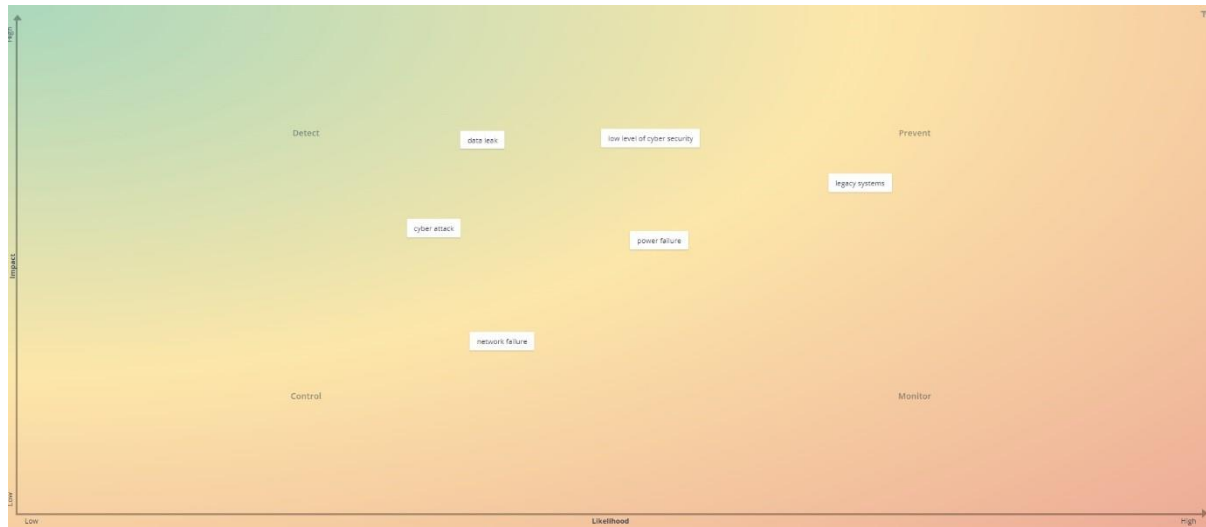
Group
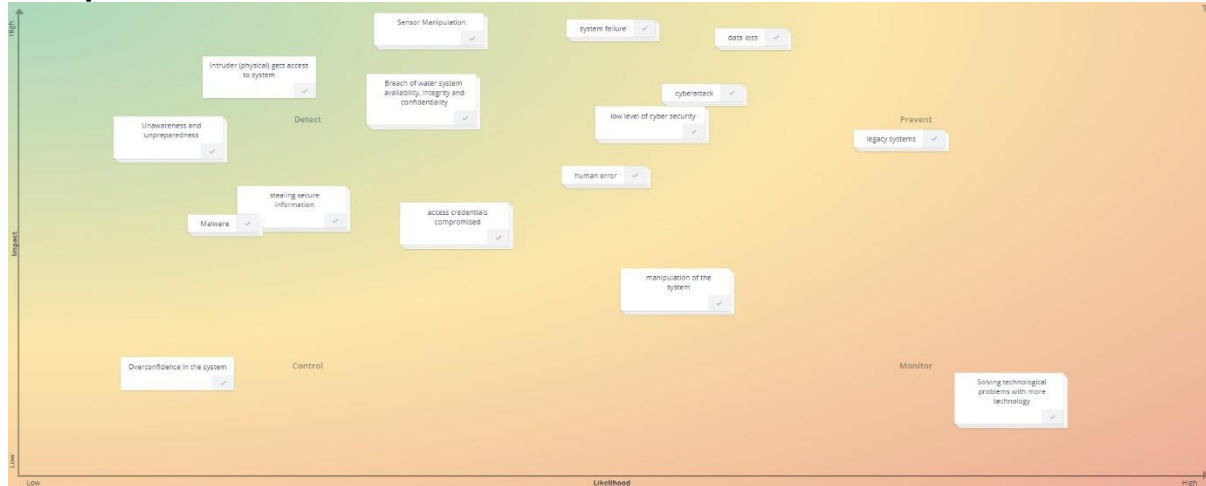
The following groups of risks have been identified:

- Unawareness and unpreparedness
  - People not educated or interested in digital security
  - Preparedness, cybersecurity awareness and training
  - Not qualified stuff
- Intruder (physical) gets access to system
- Sensor manipulation
  - Share access to sensors
  - Wrong sensor calibration
- System failure
  - Power failure
  - Network failure
  - Loss of control system
  - Failure of sewer system
  - Failure of dams/sluices so floods
- Data loss

- Cyberattack
    - Server attack
    - Website hack
    - Internal versus external hacking
    - Hacking sewer systems/sluice
    - Cyberattack on suppliers (internet provider)
    - Hacker attack
    - External access to operator monitors
- Legacy systems
    - Old systems
    - Old software
- Solving technological problems with more technology
    - AI-based intrusion prevention and detection systems
- Manipulation of the system
    - Add chemicals to system
    - Visual manipulations
    - Adding pollution/chems water
- Human error
- Low level of cyber security
    - No mail encryption
- Access credentials compromised
    - Slobby people sharing info/log in
    - Staff giving access
    - Log out all operators/log off access
    - External person gets access to the network via LAN cable or WiFi
    - Unauthorized admin access
    - Log off monitoring systems
    - Access data sharing
- Breach of water system availability, integrity and confidentiality
    - Operational data shared
    - Water quality data shared
- Stealing secure information
    - Hacking personal data from employees
    - Customer data share
    - Secured information is stolen via the printers/scanners
    - Sensitive data sharing
    - Information content security
    - Intercept money transfers
- Malware
- Overconfidence in the system
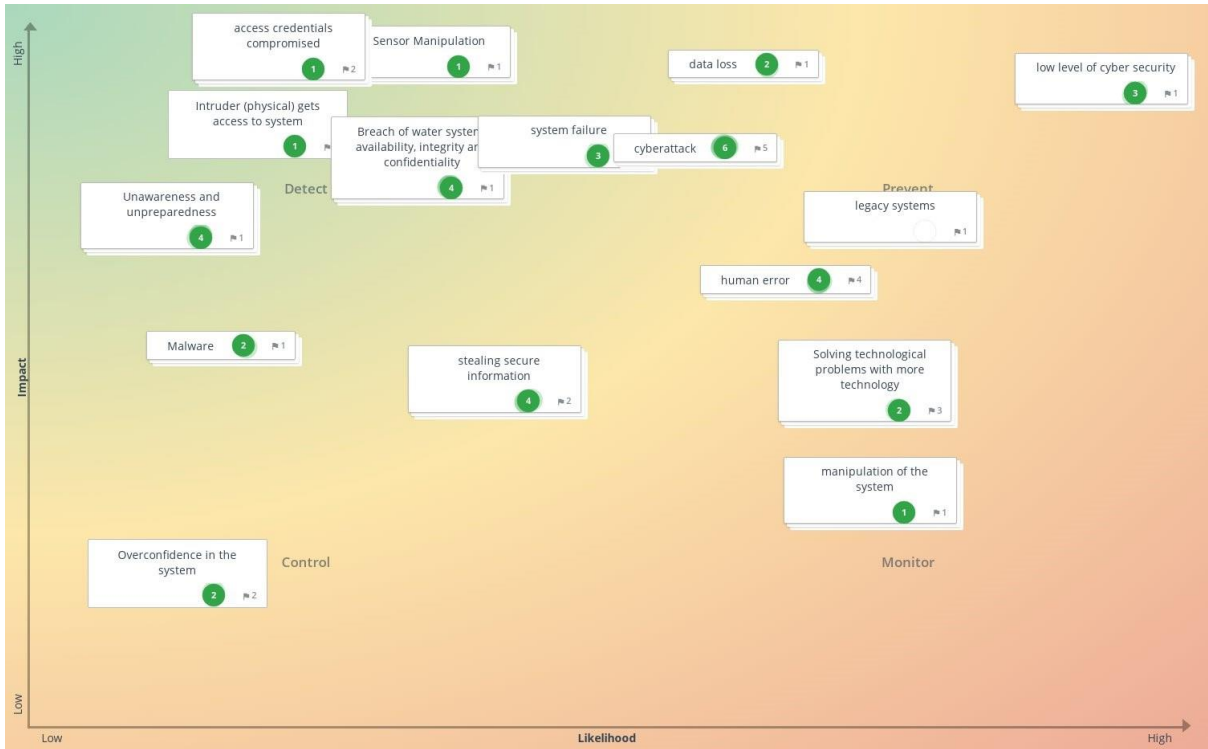
Position
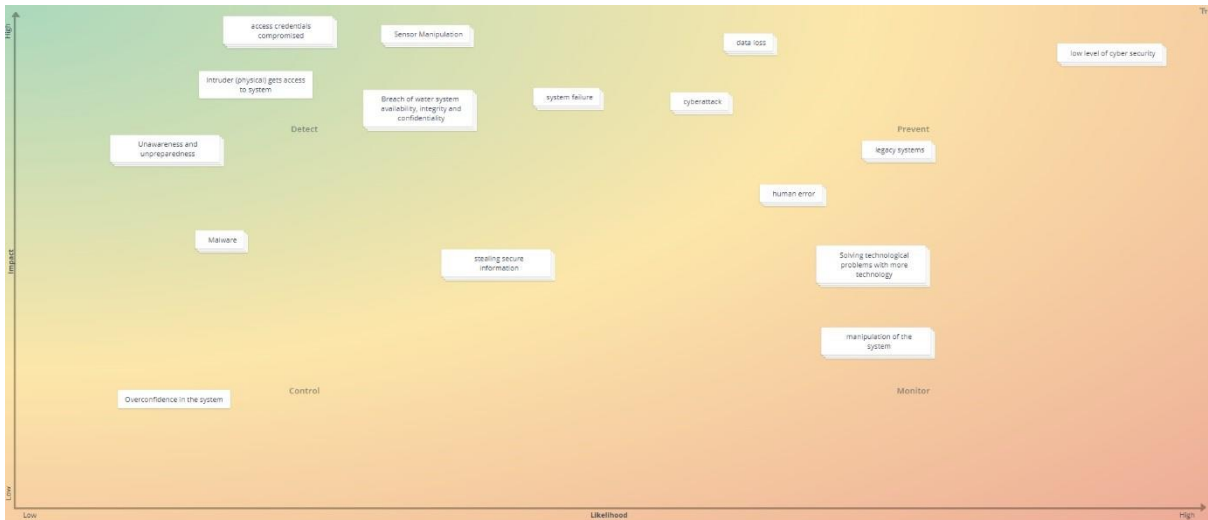
Vote

After voting the following groups had the maximum votes:

- Cyberattack (6)
- Human error (4)
- Breach of water system availability, integrity and confidentiality (4)
- Stealing secure information (4)
- Unawareness and unpreparedness (4)

Actions

Idea Title	What	Who	When
data loss	Preventative Action by making backups	the data manager	daily or weekly
human error	access control	ICT	31 Dec 2021
Solving technological problems with more technology	Add an interdisciplinary (philosophy...) module to the computer science curriculum	universities	asap?
Malware	add mail encryption	Mail provider	13 Dec 2021
Sensor Manipulation	anomaly detection	the data manager	31 Mar 2022
Access credentials compromised	Apply credential change policy	ICT dept	ASAP
Cyberattack	Better cyber security (better software eg)	Water treatment plants	ASAP :)
Intruder (physical) gets access to system	Better security protocols	Water treatment plants	
Breach of water system availability, integrity and confidentiality	close data infrastructure	telecommunication	22 Dec 2022
cyberattack	Controlling the system on weaknesses	water treatment plants	asap
Overconfidence in the system	Convince people they should not overconfidence a system	Government/experts	each quarter
stealing secure information	encrypt historical information	ICT Department	30 Apr 2022
legacy systems	exchange if funds are available	ICT Department	25 Feb 2022
system failure	Have a plan B		
system failure	Improve regulation and controlling the systems	Government/Regional	Asap
low level of cyber security	increase cyber security	ICT Department	ASAP
manipulation of the system	introduce better security protocols	water treatment plants	all the time

Overconfidence in the system	Invite ethical hackers to find failures	Utilities	each year
cyberattack	Involving IT experts to make a system that is hard to attack, and also better security system		
access credentials compromised	Minimum requirements for credentials	ICT	ASAP
human error	Organizing training with experienced people to reduce the risk of bad manipulation of the system	The organisation	yearly
Solving technological problems with more technology	Raise awareness, provide different views on the topic (political, societal, philosophical...), create space for big-picture and out-of-the-box thinking	everyone involved?	regularly
cyberattack	Regulations on cyber security and how to act on it	Government	asap
Solving technological problems with more technology	Research/ implication project on system thinking and impact of digitalization on human actions in water process	EU partners/ EC	next 4 yrs
stealing secure information	securing information	ICT Department	ASAP
human error	Specific training	Targeted for each position	Regularly updated
human error	Staff education	HR and ICT dep	on a regular basis
Unawareness and unpreparedness	Training and facilitation of personnel	Utilities	continuous

cyberattack	Use NIST Cybersecurity Framework to assess, identify, protect and detect cyber-attacks.	Water and wastewater utilities	ASAP

3.6 Workshop (6): Circular economy

3.6.1 Input
The following lecture was used as an input for this workshop:

- Circular bioeconomy approaches in wastewater management by Pelin Kocaturk Schumacher.

The group work was based on chitchat format to discuss the overly heard terminologies of sustainability, resource recovery, circular economy and bio economy where each group was asked to contemplate about one term.

3.6.2 Task
The task was to think/talk about the meaning of the following terms: Sustainability, resource recovery, circular economy, bioeconomy.

3.6.3 The augmented collaboration tools
No collaboration tools were used in this workshop.

3.6.4 Debriefing
The participants were divided into 6 groups and a spoke person was assigned from each group. The discussion among the group members took 8 minutes with 2 minutes for the spoke person to debrief.

Sustainability

(Group 1 and 2 spoke persons)

Meeting our own needs without compromising the ability of future generations to meet their own needs.

In other words, avoidance of the depletion of natural resources in order to maintain an ecological balance.

Examples:

Sustainable energy production → to replace fossil fuels

Water conservation

→ About 70 percent of the world's fresh water is used for agriculture

Resource recovery

(Group 3 and 4 spoke persons)

- **Resource recovery**: The retrieval of recyclable waste, which was intended for disposal. Waste is retrieved for a specific next use - serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function

- **Reuse**: Reusing a certain material means to use it again for the same purpose that it was originally made for.

- **Recycling** is the process of recovering material from waste and turning it into new products, materials or substances whether for the original or other purposes.

Bioeconomy

(Group 5 spoke person)

European Commission, 2018:

"The bioeconomy covers **all sectors and systems** that rely on **biological resources** (animals, plants, micro-organisms and derived biomass, **including organic waste**), their functions and principles.

It includes and interlinks:

- land and marine ecosystems and the services they provide;

- all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture);

- all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services"
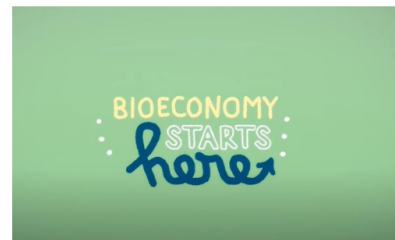
Video: The Bioeconomy starts here!

Circular economy

(Group 6 spoke person)

The concept of the circular economy is about **using** planet's **resources efficiently and sustainably** to **prevent** irreversible **environmental degradation** and **resource depletion.**

The circular economy:
A new way to design, make, and use things

From waste to resource

Circular bioeconomy
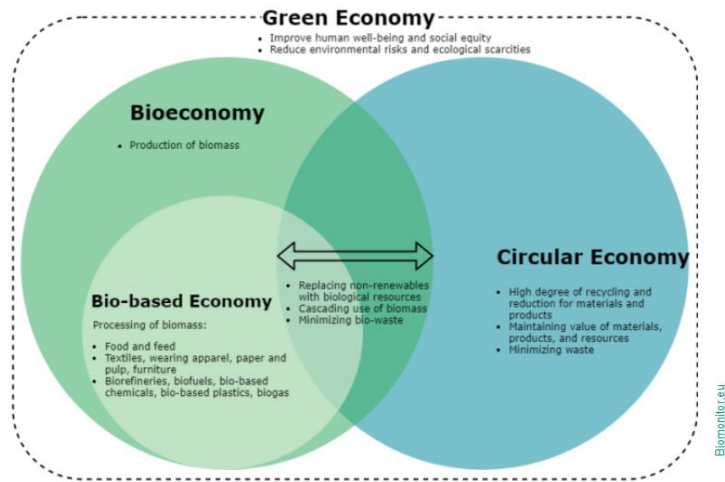
Figure 3: VENN diagram of Bioeconomy, bio-based economy, green economy and circular economy

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Annex: The evaluation of the workshops
- University of Nis evaluation of workshop (1)

University of Nis tested this workshop with 28 participants. A questionnaire was created to evaluate the implemented workshop including 16 questions. In total, 24 responses have been received.
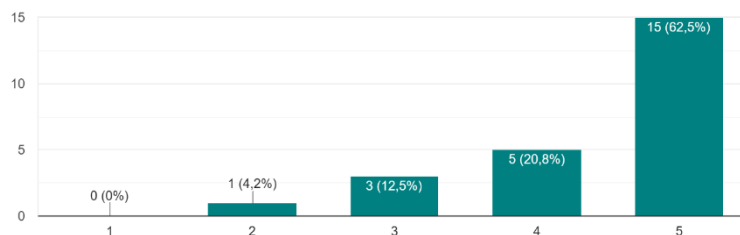
1. Did you find the workshop interesting? (1-Not at all, 5-Yes, very much)

Da li Vam je tema radionice bila zanimljiva?
24 одговора
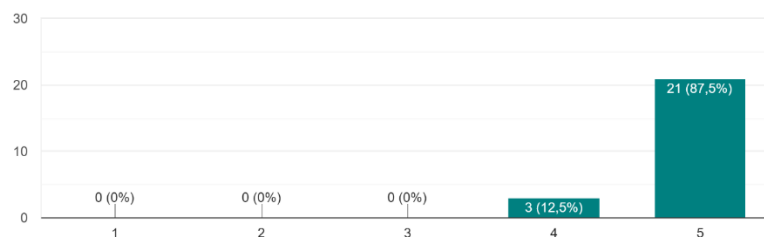
2. Do you think that the topic of the workshop is current? (1-Not at all, 5-Yes, very much)

Da li mislite da je tema radionice aktuelna?
24 одговора

3. All in all, are you satisfied that you participated in this workshop? (1-Not at all, 5-Yes, very much)

Da li ste u celini zadovoljni učešćem u radionici?
24 одговора
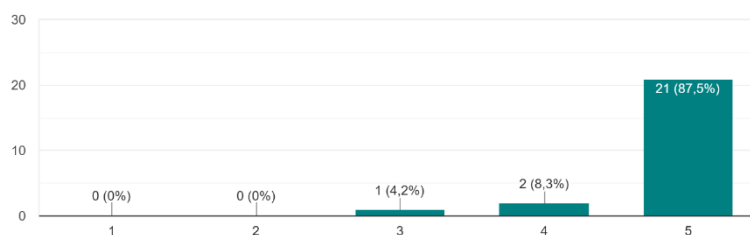
4. Did you find the workshop material interesting (video clips, slides…)? (1-Not at all, 5-Yes, very much)

Da li Vam je bio interesantan pripremljeni materijal (video snimci, slajdovi...)?
24 одговора
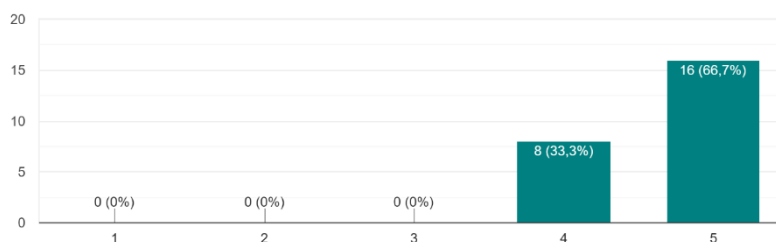
5. Did you enjoy the group assignment? (1-Not at all, 5-Yes, very much)

Da li Vam se dopao grupni zadatak koji je trebalo da uradite u toku radionice?
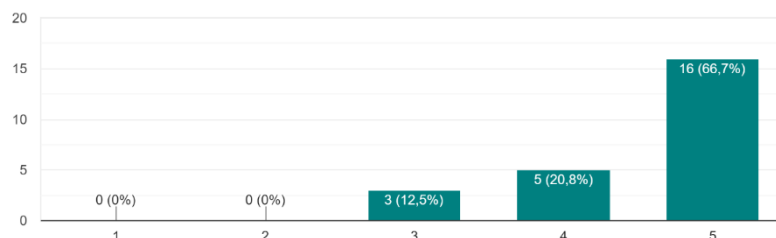24 одговора
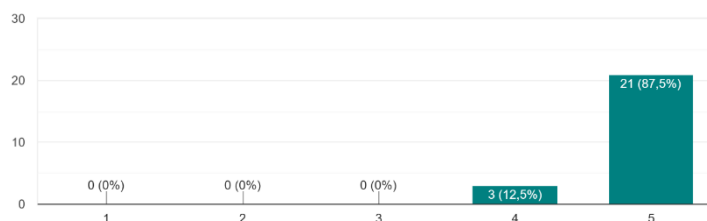
6. Do you feel that you were provided with enough input material to help you perform the group assignment? (1-Not at all, 5-Yes, very much)

Da li se smatrate da Vam je predstavljeno dovoljno materijala da biste mogli uspešno da uradite grupni zadatak?
24 одговора
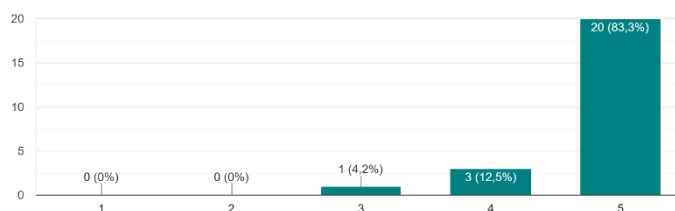
7. Do you think that it is a good thing that the group assignment was performed without moderators' involvement? (1-Not at all, 5-Yes, very much)

Da li mislite da je dobro što ste grupni zadatak radili bez učešća i prisustva profesora i asistenta?
24 одговора

8. Were you satisfied with the role distribution for the group assignment? (1-Not at all, 5-Yes, very much)
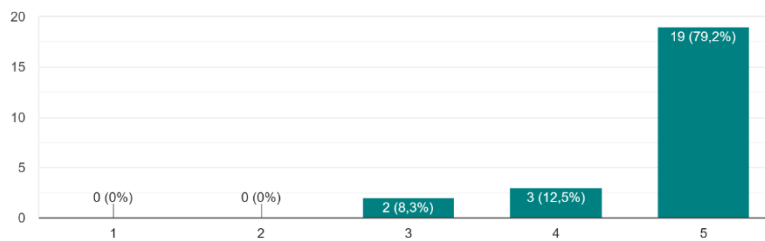
Da li ste zadovoljni podelom uloga u okviru grupe tokom rađenja grupnog zadatka?
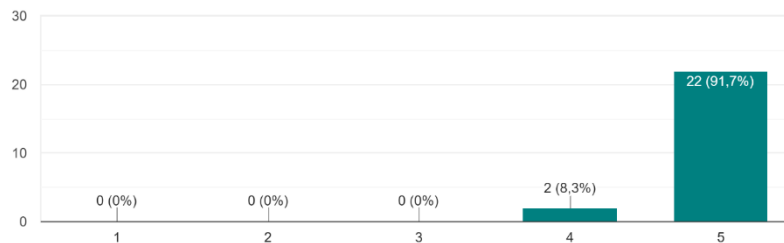24 одговора
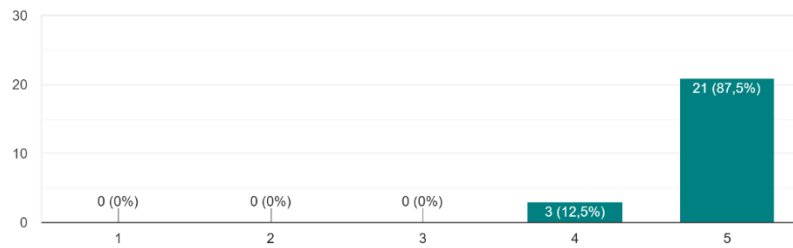
9. Are you satisfied with your personal contribution to the workshop (discussion, group assignment…)? (1-Not at all, 5-Yes, very much)

**Da li ste zadovoljni svojim doprinosom u radionici (diskusija, grupni zadatak,...)?**
24 одговора

10. Did you like the joint discussion of identified factors and the voting? (1-Not at all, 5-Yes, very much)

Da li Vam se dopala zajednička diskusija o identifikovanim faktorima i glasanje?
24 одговора

11. Do you consider that more time should have been allocated for the group assignment? (1-Not at all, 5-Yes, very much)

Da li smatrate da je bilo potrebno više vremena za izvođenje grupnog zadatka?
24 одговора
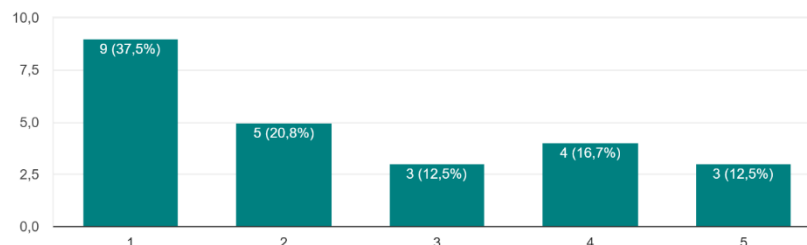
12. Do you consider that more time should have been allocated for the discussion about identified factors and their significance? (1-Not at all, 5-Yes, very much)

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Da li smatrate da je bilo potrebno više vremena za diskusiju o pojedinim identifikovanim faktorima i njihovoj značajnosti?
24 одговора
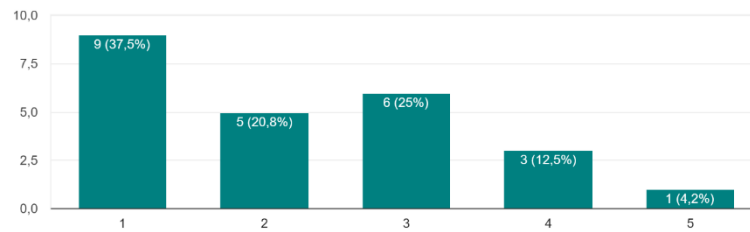
13. Do you think it is a good idea to allow participants to give feedback about the workshop in the final segment of the workshop? (1-Not at all, 5-Yes, very much)

Da li mislite da bi bilo dobro da u poslednjem delu radionice učesnici mogu da daju komentare o samoj radionici?
24 одговора
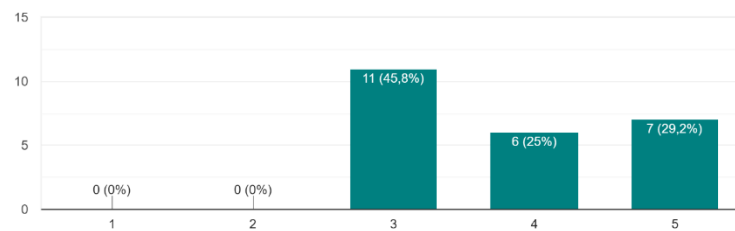
14. What do you think was good in the workshop? (10 responses)

- The entire organization of the workshop was interesting and good.

- The workshop was well organized and interesting.

- I liked the discussion and the whole idea. I haven't participated in online workshops before.

- Everything was very good.

- The conversation will contribute to the higher level of awareness of global problems in community and individuals.

- Raising awareness of global problems.

- Teamwork without moderators

- Teamwork

- The whole workshop was interesting: group assignment with colleagues, videos and slides.

- The workshop was interesting, and it was well organized.

15. What in the workshop didn't you like? (2 responses)

- Everything was completely good.

- Everything was good.

16. Do you have some suggestions as to what can be changed/added to make the workshop more interesting and better? (4 responses)

- No, everything was ok.

- Everything seems to be in its place.

- To provide complete input material in Serbian. It wasn't a problem for me personally, but I know that others had a problem understanding.

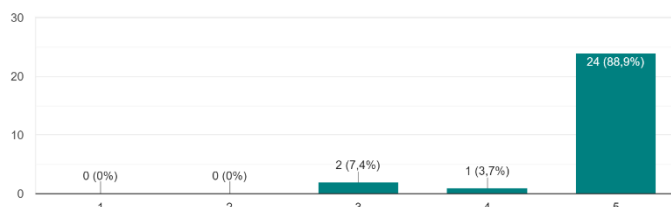- Picking group members ourselves.

University of Nis tested this workshop with 33 participants. A questionnaire of 16 questions was created for the evaluation process. In total, 27 responses have been received.
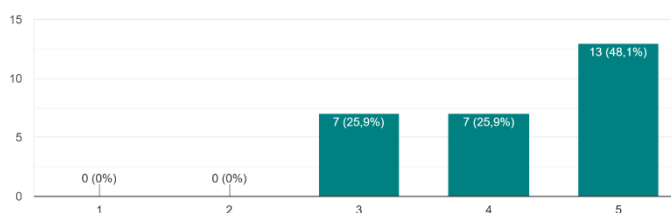
1. Did you find the workshop interesting? (1-Not at all, 5-Yes, very much)

Da li Vam je tema radionice bila zanimljiva?
27 одговора

0 (0%)	0 (0%)	2 (7,4%)	1 (3,7%)	24 (88,9%)
1	2	3	4	5

2. Do you think that the topic of the workshop is current? (1-Not at all, 5-Yes, very much)

Da li mislite da je tema radionice aktuelna?
27 одговора

0 (0%)	0 (0%)	7 (25,9%)	7 (25,9%)	13 (48,1%)
1	2	3	4	5

3. All in all, are you satisfied that you participated in this workshop? (1-Not at all, 5-Yes, very much)

Da li ste u celini zadovoljni učešćem u radionici?
27 одговора

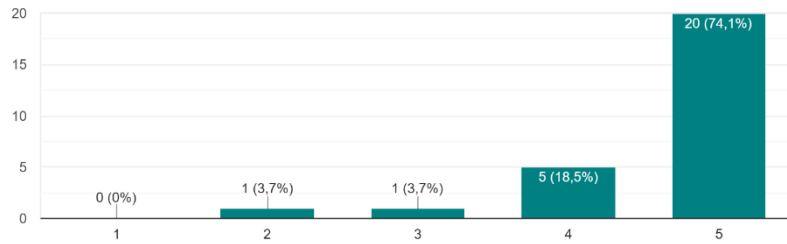|				
0 (0%)	0 (0%)	4 (14,8%)	5 (18,5%)	18 (66,7%)
1	2	3	4	5
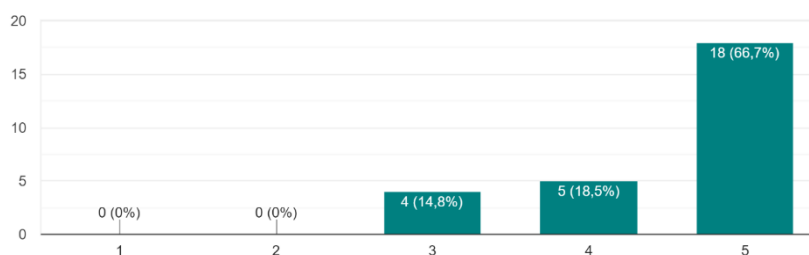
4. Did you find the workshop material interesting (video clips, slides…)? (1-Not at all, 5-Yes, very much)

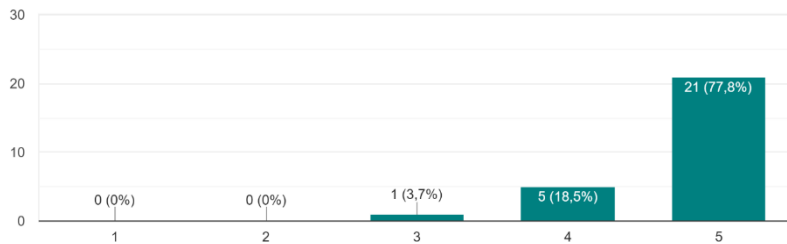Da li Vam je bio interesantan pripremljeni materijal (video snimci, slajdovi...)?
27 одговора

5. Did you enjoy the group assignment? (1-Not at all, 5-Yes, very much)

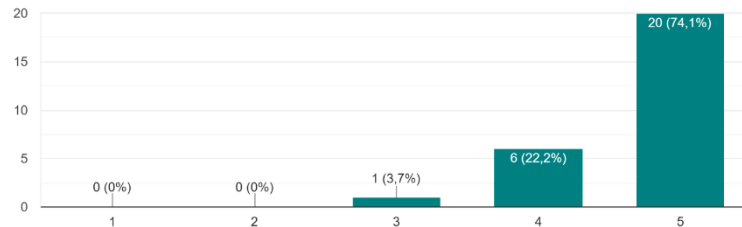Da li Vam se dopao grupni zadatak koji je trebalo da uradite u toku radionice?
27 одговора

6. Do you feel that you were provided with enough input material to help you perform the group assignment? (1-Not at all, 5-Yes, very much)

Da li se smatrate da Vam je predstavljeno dovoljno materijala da biste mogli uspešno da uradite grupni zadatak?
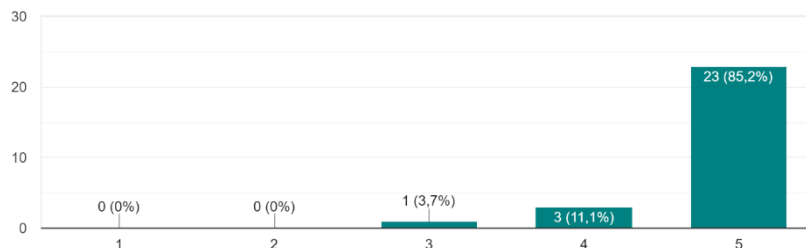27 одговора

7. Do you think that it is a good thing that the group assignment was performed without moderators' involvement? (1-Not at all, 5-Yes, very much)

Da li mislite da je dobro što ste grupni zadatak radili bez učešća i prisustva profesora i asistenta?
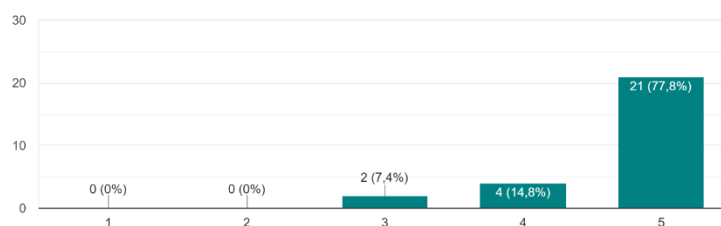27 одговора

8. Were you satisfied with the role distribution for the group assignment? (1-Not at all, 5-Yes, very much)
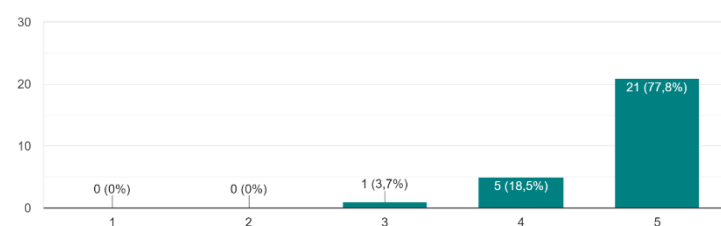
Da li ste zadovoljni podelom uloga u okviru grupe tokom rađenja grupnog zadatka?
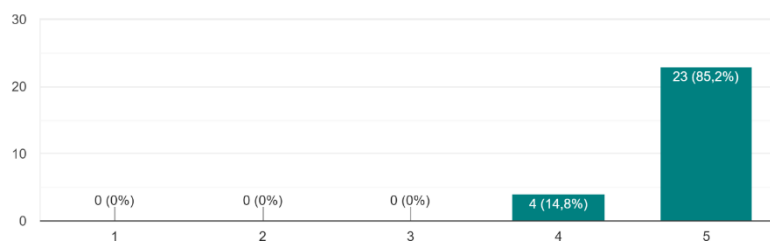27 одговора

30

20   21 (77,8%)

10

0   0 (0%)   0 (0%)   2 (7,4%)   4 (14,8%)
          1   2   3   4   5

9. Are you satisfied with your personal contribution to the workshop (discussion, group assignment…)? (1-Not at all, 5-Yes, very much)

Da li ste zadovoljni svojim doprinosom u radionici (diskusija, grupni zadatak,...)?
27 одговора

30

20   21 (77,8%)

10

0   0 (0%)   0 (0%)   1 (3,7%)   5 (18,5%)
   1   2   3   4   5

10. Did you like the joint discussion of group assignment results? (1-Not at all, 5-Yes, very much)

Da li Vam se dopala zajednička diskusija o dobijenim rezultatima grupnog zadatka?
27 одговора

30

20   23 (85,2%)

10

0   0 (0%)   0 (0%)   0 (0%)   4 (14,8%)
          1   2   3   4   5

11. Do you consider that more time should have been allocated for the group assignment? (1-Not at all, 5-Yes, very much)
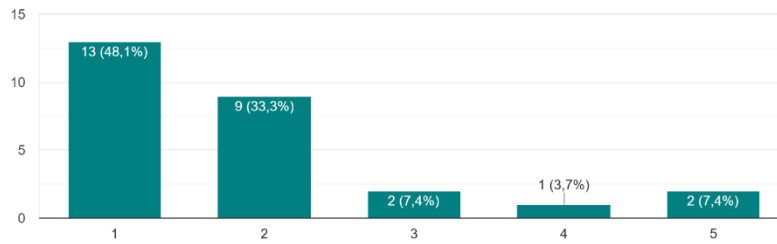
Da li smatrate da je bilo potrebno više vremena za izvođenje grupnog zadatka?
27 одговора

15

10   11 (40,7%)

5   7 (25,9%)
                                           6 (22,2%)

0   1 (3,7%)   2 (7,4%)
          1   2   3   4   5
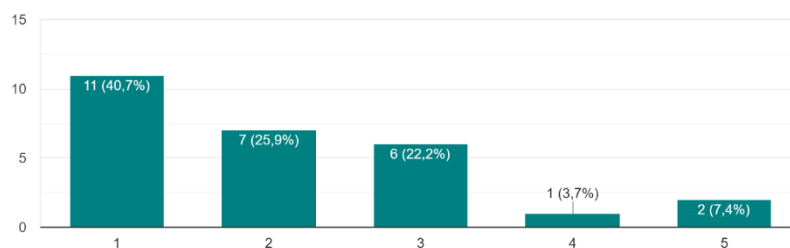
12. Do you consider that more time should have been allocated for the discussion about group assignment results? (1-Not at all, 5-Yes, very much)

Da li smatrate da je bilo potrebno više vremena za diskusiju o rezultatima svake grupe?
27 одговора

13. Do you think it is a good idea to allow participants to give feedback about the workshop in the final segment of the workshop? (1-Not at all, 5-Yes, very much)

Da li mislite da bi bilo dobro da u poslednjem delu radionice učesnici mogu da daju komentare o samoj radionici?
27 одговора
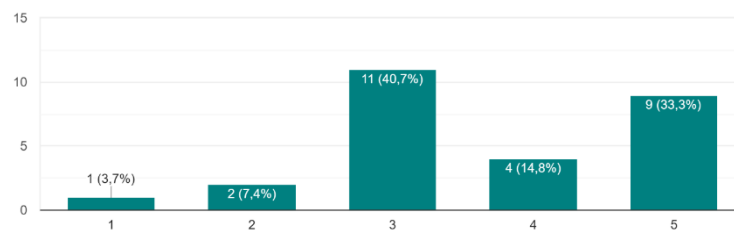
14. What do you think was good in the workshop? (6 responses)

- Group work and the current topic.
- The workshop was interesting, especially the game.
- Organized team work.
- Everything was great and well organized.
- Everything was good.
- Group work, presentations and slides, as well as the whole organization.

15. What in the workshop didn't you like? (2 responses)

- Everything was good
- Everything was ok

16. Do you have some suggestions as to what can be changed/added to make the workshop more interesting and better? (2 responses)

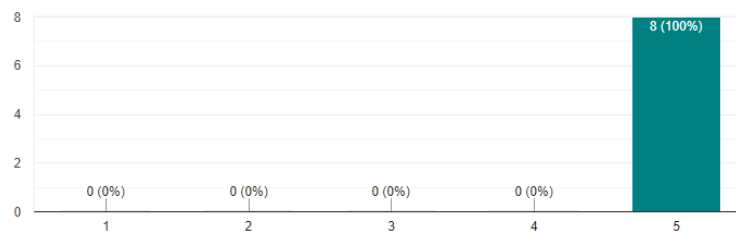- A bit more explanation about the game
- No

- University of Nis evaluation of workshop (5)

In order to evaluate implemented workshop, the Google form was created including 13 questions. In total, 8 responses have been received.
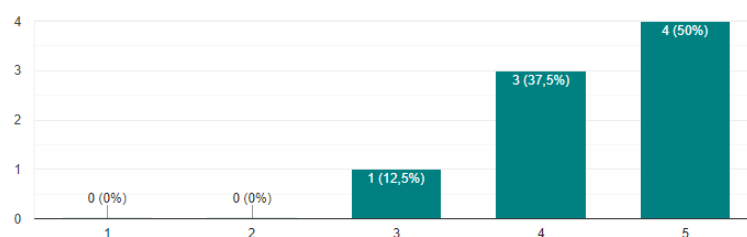
Do you think that the topic of the workshop is current?
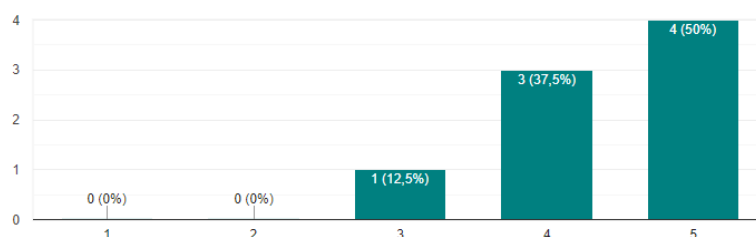
8 одговора

Did you find the workshop material interesting (video clips, slides...)?
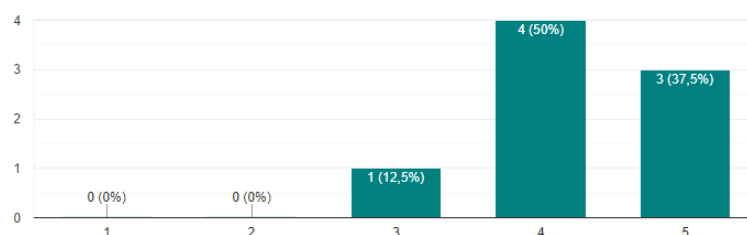
8 одговора

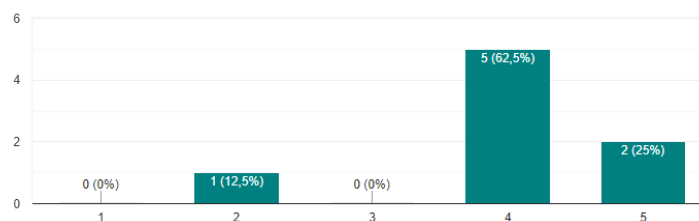All in all, are you satisfied that you participated in this workshop?

8 одговора

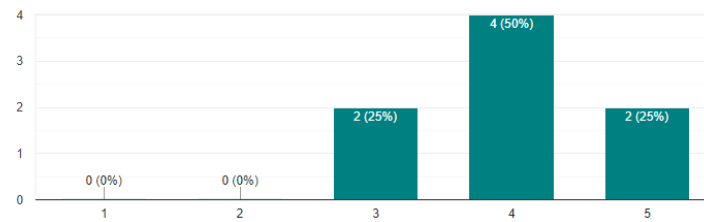Did you enjoy the group assignment?

8 одговора

Do you feel that you were provided with enough input material to help you perform the group assignment?
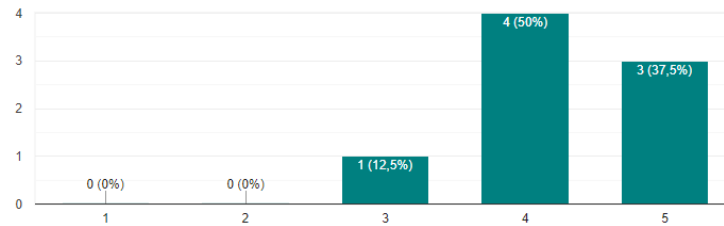
8 одговора

Are you satisfied with your personal contribution to the workshop (discussion, group assignment...)?
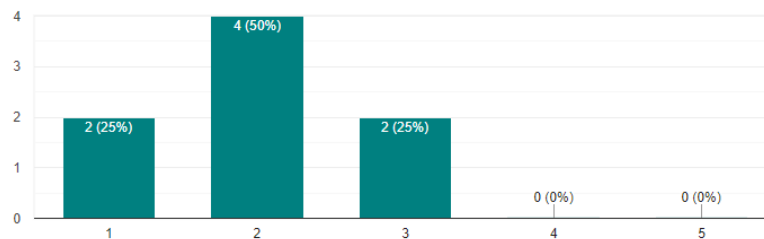
8 одговора

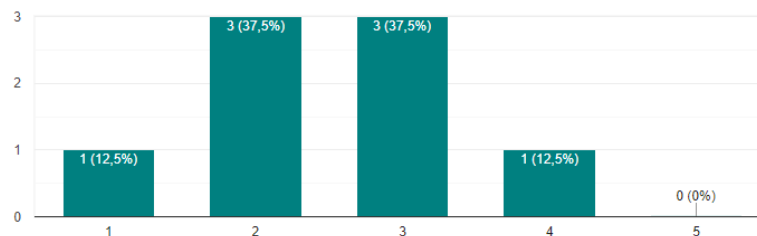Did you like the joint discussion of group assignment results?

8 одговора

Do you consider that more time should have been allocated for the group assignment?

8 одговора

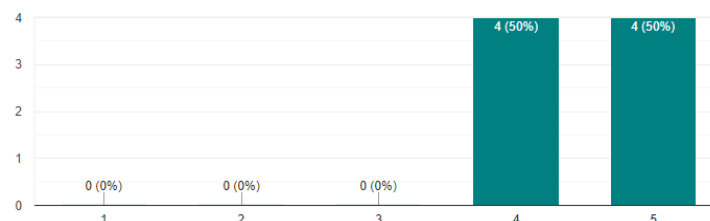Do you consider that more time should have been allocated for the discussion about results?

8 одговора

Do you think it is a good idea to allow participant to give feedback about the workshop in the final segment of the workshop?

8 одговора

What do you think was good in the workshop? (8 responses)

- The structure and creating an interactive environment

- Giving supporting information before starting the practical part.

- the groupmap.com exercise was very interesting

- Nice ideas and discussion how to change and upgrade the systems

- I really like the topic and the way of working via GroupMap

- The combination of presentation and work in group.

- An important issue that we have to be more aware of.

- Integration and space for everyone to contribute

- What in the workshop didn't you like? (8 responses)

- I have limited knowledge about this topic, so I couldn't fully participate in answering the questions.

- The goal of the workshop wasn't completely clear.

- The first questions in Mentimeter, they are difficult to answer for someone who is not working in digitalization

- Nothing it was good :)

- Too much time was given for the first question (I think 5 min would be enough)

- I would have liked to see the path of data/information from sensor, over gateway, network, server, PLC, SCADA.... with the different tools protocols/data base/data analysis

- A bit more in-depth discussion on possible solutions would make it better - also hear more personal stories and experiences to apply and become aware.

Do you have some suggestions as to what can be changed/added to make the workshop more interesting and better? (6 responses)

- Make the evaluation form anonymous, to make sure people answer it with maximum honesty

- Maybe to show the results graphically

- To create more interaction, split the group up in smaller groups that come up with some ideas. Now you had to categorize all the answers. It is nicer if you have less answers but are discussed and offered as a group. Then you can ask the group to present their results/problems and actions instead of overgo the answers on the page.

- Everything was good :)

- A more practical workshop on some issues

- Facilitate the process on GroupMap more - engage the conversation during the brainstorm time.

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