Capacity Building in Water with Serious Games

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Abstract Serious games are not a new concept, but serious games using real-life data-coupled with real-time modelling and combining the model results with social and economic factors opens up a new paradigm for active stakeholder participation and education. Aqua Republica combines a game layer with a water allocation model, MIKE HYDRO, to create an interactive, realistic virtual environment where players play the role of a democratic leader of a river catchment. Different versions of the game are developed to support different interests. Examples include a version for educating school-age children, a version for stakeholder participation workshops and a version for raising awareness

Keywords Serious games · IWRM · Trans-boundary · Governance · Capacity building · ICT

Serious games are not a new concept, but serious games using real-life data—coupled with real-time modeling and combining model results with social and economic factors—open up a new paradigm for active stakeholder participation and education. In 2012, DHI and UNEP-DHI Centre embarked on an initiative called Aqua Republica, where participants are expected to develop a virtual world based around a river basin where a limited amount of water needs to be shared between competing users and uses. The aim is to raise awareness of the importance and

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interconnectivity of water, as well as educating about how it can be more sustainably managed through integrated water resources management (IWRM).

Aqua Republica combines a game layer with a water allocation model, MIKE HYDRO (DHI 2013), to create an interactive, realistic virtual environment where players play the role of a democratic leader of, what is initially, undeveloped river catchment. The main objective is to sustainably manage the river catchment, so the inhabitants become as materially and spiritually prosperous as they can be. To achieve that, players need to drive the catchment's economy to provide the funds needed for further development and have a steady food supply for a growing population and enough energy and water to maintain both growth and environmental services. Players are engaged and educated about the relationships between developmental actions in a river basin—as well as their consequences. The game layer also consists of a reward system to encourage learning through competition and more positive actions. For example, a player who takes care of the ecosystem while developing the catchment gets a bonus score and gets a rewarding event, while a player who does not will encounter pollution events, will need to spend more resources on cleaning up, and will ultimately receive a lower score. Such game mechanics are designed to engage people and increase their interest in sustainable water resources management.

Different versions of the Aqua Republica game are developed to support different interests. Examples include a version for educating school-age children, a version for stakeholder participation in workshops, and a version for raising awareness within certain sectors or business interests.

1 Introduction

According to the 2012 UN Water Status Report (UNEP 2012a) on the Application of Integrated Approaches to Water Resources Management, 82 % of countries are implementing changes to their water laws for a more integrated approach to water resources management. This probably indicates that there is general consensus on the importance of the issue. However, according to the same report, only 35 % of the countries have sufficient training programs for IWRM—the accepted approach for managing water sustainably. That is a massive gap between the will and the capacity to solve water problems. It is obvious that we need to narrow this gap, but how do we do that?

Capacity-building programs and training programs have been going on for many years, and education is a complex and continuous process; nevertheless, there is a constant push to try to find new ways to make these efforts more efficient, effective, and scalable in order to achieve the desired progress. A major opportunity to accelerate progress is through the utilization of opportunities provided by advances in and dissemination of information and communications technology (ICT).

One of the main upsides of digital communication and information is the accessibility; for example, the ability to communicate socially, organize financial

transactions, and keep up to date with the very latest local and international news is becoming more and more commonplace for people on all income levels. One of the main downsides of digital communication is the overabundance of information; for example, consider the number of hits a search engine returns on a simple search, or the amount of online advertisements a typical Internet user may be exposed to during the course of day. At the same time, as more and more information becomes available on the Internet, nothing is ever deleted. We are exposed to these sources at such a high rate that it affects the way our brains process information (Small and Vorgan 2008; Gee 2003a and 2003b). According to Small and Vorgan (2003), daily exposure to high technology—computers, smartphones, video games, and search engines—stimulates brain cell alteration and neurotransmitter release, gradually strengthening new neural pathways in our brains while weakening old ones. Today, every single source of information, be it books and papers, Webpages, television programs, podcasts, YouTube videos, short messages (SMS), Facebook notifications and so on, competes for our attention, and the most interactive and engaging one normally wins.

With this as a backdrop, we now face additional challenges in capacity building; besides having to make it more efficient and scalable and so on, we also need to keep up with communication trends and technology to be able to attract the attention and interests of our target audience.

If we consider where capacity building starts, at school, and think about our own experiences and those of our classmates, we can all easily recall that in general there is a big difference between what motivates students. Typically, children are motivated by activities that they consider to be fun, and often less so with formal activities and associated materials that schools consider of greatest importance (after Stapleton and Taylor 2002, 2003; Stapleton 2004; Shute et al. 2009). A desirable approach is one where the fun activity part is combined with the topics traditionally included in the more formal activities, in order to increase the potential for learning.

Such an approach is applied through serious gaming, and it is being used with success in many different fields ranging, for example, from health care and city planning, to engineering and religion. In this paper, we will take a look at an interactive approach to capacity development with the use of serious games in the field of water and especially so in IWRM.

2 What Is Serious Gaming?

When we encounter a problem, it is always wise to go back to the fundamentals. That leads us to a quote from Confucius, a Chinese philosopher who once said “I hear and I forget. I see and I remember. I do and I understand.” The keywords are doing and understanding, but how could we do or practice IWRM?

Imagine a virtual world that mimics the complexity of the real world, in terms of water environments. A virtual world which allows us to test out development plans, test out new regulations, visualize the potential impacts, make mistakes, and as a result learn through personal experience. This is the concept of serious gaming.

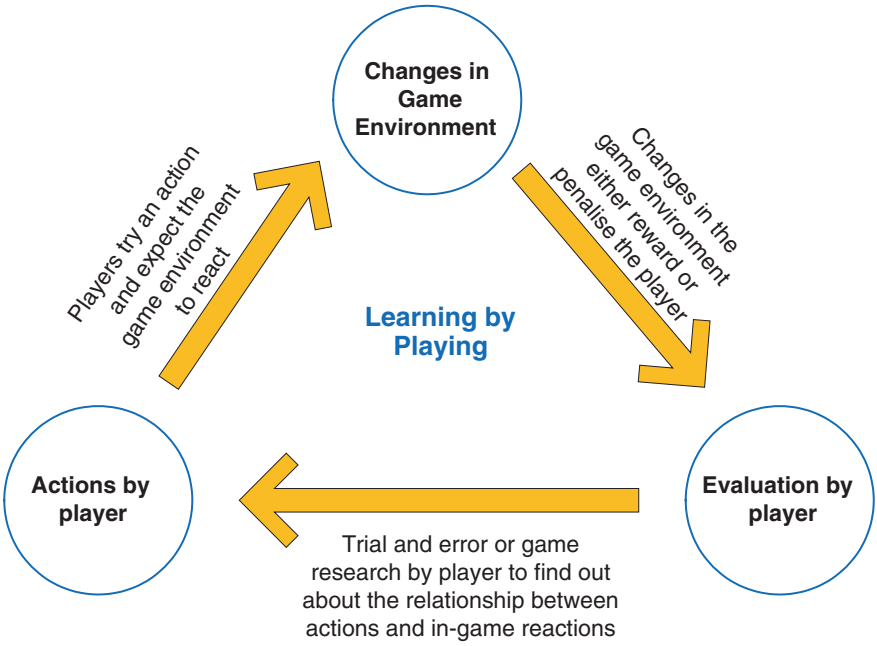

Fig. 1 The cycle of learning by playing

A serious game is a category of games that are designed with the intention to teach rather than for pure entertainment, whereas a casual game is defined here as a game for pure entertainment. However, it does not mean that serious games cannot be entertaining. Serious games that are well designed yield "meaningful play," a condition very much like learning. According to Salen and Zimmerman (2004), meaningful play is when the relationships between actions and outcomes in a game are both discernible and integrated in the larger context of the game. Serious games also shift the focus of control in learning from the teacher to the player and create an environment that stimulates learning, often resulting in an increase in self-learning and knowledge retention (Fig. 1).

While learning can occur within a casual game, it is a by-product rather than the intended outcome of the gameplay. Both types of games vary in different forms of genres, platforms, and story lines, but a good game, whether it is a serious game or a casual game, has enough challenges and rewards, as well as entertainment value to keep players' attention.

When describing the distinct difference in the two types of a game, it holds true that the devil is in the detail. A serious game is embedded in a realistic context, whereas a casual game may use a realistic context as a way to create a more believable game. This becomes clearer as we look at some of the key components of how games work on low level.

Games are interactive, which is what makes them different from traditional media. However, interactivity itself is meaningless without a context. Opening

or closing a door is interactivity, you interact with the door, but whether or not it makes sense requires that there is something we are striving toward—a goal. If we want to conserve heat by not letting cold air into the house, the interaction of closing the door is suddenly meaningful.

Games thus are interactive and have a goal. This is true for all types of games. The last part to making a game is to combine the purposeful interaction with opposition. Opposition forces the player to make choices; the type of choice that the player has to make is often part of deciding which genre label is put on a game. Shooting games require quick twitch actions, and many of the choices made are almost subconscious, duck, jump, or sprint to the next piece of cover and such. Turn-based strategy games involve choice based on the analysis of the current state of game and the range of possible actions based on current resources and an understanding of how current actions change the game state—for example, chess.

Games also have a structure. In a typical board game, the structure would be the rules which you play by. In a digital game, the structure defines what you can do within the game and how the feedback loops work. The structure defines which actions you can take in order to overcome the opposition and reach your goal.

Every game also conveys information, which is passed on to the player. The information is needed for the player to make choices; without information, the choices will be random and that will quickly grow boring; since then, it is not you overcoming the opposition; then, you might as well have flipped a coin in the beginning to determine the outcome.

The above is still part of games whether they are considered serious or casual, but we are getting closer to the part where they branch. The nature of the games being a visual interactive environment with its own structure and feedback mechanisms also means that games "create their own meaning" also called "endogenous meaning" in an article by Costikyan (2002). For example, consider that a big white box with a red cross on it means that one gets 100 points for each hit as part of a shooting game. This gameplay logic makes sense within the game, but is not a lesson that can be readily transferred and applied in the real world. This is where serious games tend to stand apart.

The meaning created in a serious game and the verbiage used to describe it should have a relationship to the subject matter it is trying learn the player about. So that if a player is asked to describe what happened in the game, this description will have roots in real life. This is achieved by making the structure, goals, and information received by the player through play related to the topic at hand.

3 About Aqua Republica

Aqua Republica is a DHI and UNEP-DHI Centre initiative that focuses on the development and promotion of a not-for-profit serious game in collaboration with a number of partners. The rationale for producing the game is to promote sustainable water resources management by sharing knowledge, raising awareness, and building

capacity in some of the most critical issues in water resources management through serious gaming. This is achieved through a computer-generated virtual environment called, "Aqua Republica" where participants can experience making decisions in managing a catchment in an interactive and engaging way, and in doing so learn about the importance and interconnectivity of water and its uses, as well as it can be sustainably managed. While the world of Aqua Republica is fictitious, the challenges of sustainably managing a limited supply of water resources in a situation of growing demand between multiple users and uses are very much based on real-life scenarios.

The Aqua Republica game is designed to be a powerful teaching tool, which uses a reward system to encourage learning and desirable behavior. It is designed to engage people and increase both their knowledge and their interest in water-related issues. The ambition is to continuously develop Aqua Republica in multiple versions which have both broad and very specific appeal to a wide range of people and contexts.

The game goal in Aqua Republica is to achieve the highest score possible. This is achieved by employing a strategy which seeks to balance water consumption between different water users and uses, while caring for freshwater ecosystems which serve as sources of supply. The game, including the logic behind it, is built upon an engine that realistically simulates the flow of water in a catchment. This engine is used to support feedback to the player. For example, players are alerted if water use starts to become out of balance with demands or if supply is threatened. Players are also encouraged and guided toward appropriate types of remedial action.

Different versions of the game are developed to support different interests, for example, a version for educating school-age children, a version for a stakeholder participation workshop, and a version for raising awareness within certain sectors or business interests.

The following sections of the paper break down the game into a virtual environment and a learning environment and explain in more detail how they support learning.

4 Virtual Environment

The core of Aqua Republica revolves around the virtual environment; this virtual environment tries to simulate a simplified version of the real world. The virtual environment consists of 2 layers—a water allocation-and-hydrology model-based layer and a game layer which uses the results of the model and links it to social, economic, and environmental factors.

The water allocation and hydrology model is powered by MIKE HYDRO by DHI, while the game layer has been developed by a team of water experts. MIKE HYDRO's main application in the real world is to provide solutions to water allocation and water shortage problems, improving and optimizing reservoir and hydropower operations, exploring conjunctive use of groundwater and surface water, evaluating and improving irrigation performance, solving multicriteria

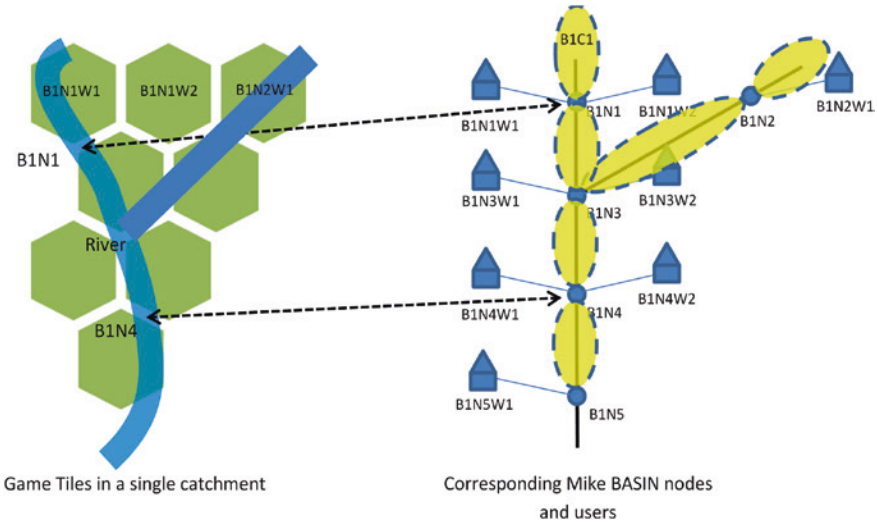

Fig. 2 A schematic view of how a map tile in Aqua Republica (*left*) links up to a node in the corresponding MIKE HYDRO basin model (*right*)

optimization problems, and establishing cost-effective measures for water quality compliance. The concept of linking up the numerical model is simple; the game map is linked dynamically as an input to the numerical model, and any actions on the game will affect the water use of each node in the numerical model (Fig. 2).

Using MIKE HYDRO as the back-end model to calculate water allocation and hydrology provides a lot of benefits:

- It allows us to use the following information in a game, such as
  - Digital elevation model (DEM) of the area
  - Shape files of the river network
  - Delimitation of the subcatchments
  - Runoff data
  - Evaporation losses, level–area–volume curve, bottom level, top of dead storage dam crest elevation, and minimum and maximum release of reservoirs
- It allows us to use realistic water demands for various types of water users or buildings in the game (e.g., crops, irrigation, and various industries)
- It gives us an accurate representation of how water is interacting in a catchment (e.g., upstream and downstream relationships)

The game layer uses the results from MIKE BASIN and affects the social–economic factors in the game. Figure 3 summarizes the interactions in the game that makes up the game layer (Fig. 4).

The game layer consists of several indicators. In this example, the focus is on population, funds, food, energy, ecosystem state, and water. Every indicator can be linked to one or many different structures like the following:

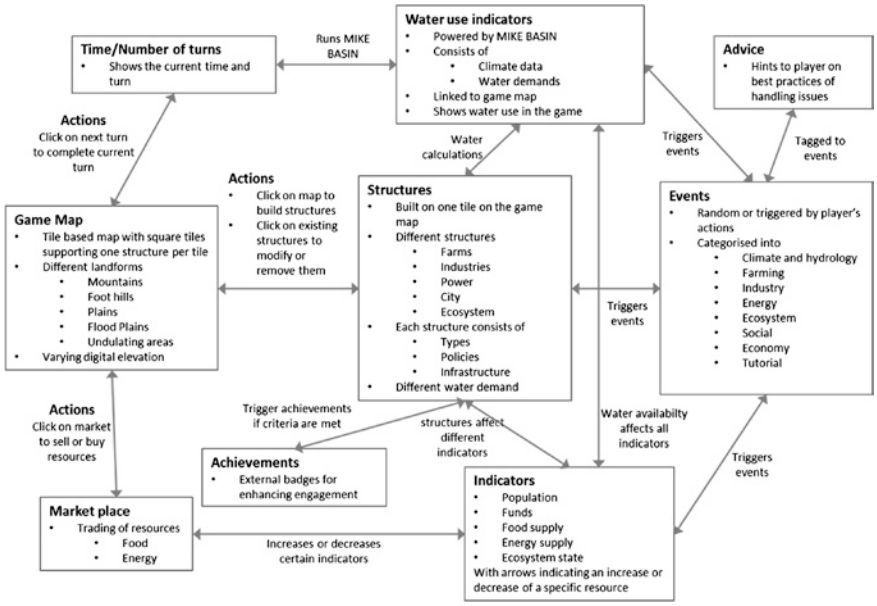

Fig. 3 Game interactions in Aqua Republica that constitutes the game layer. This game layer uses results from MIKE HYDRO basin to process socioeconomic factors

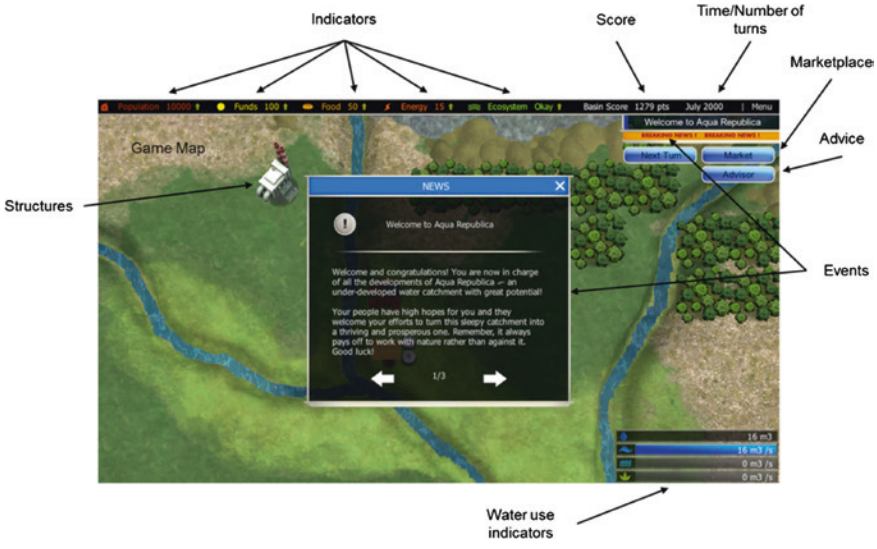

Fig. 4 Example game features of Aqua Republica

- Population
  - Each city in Aqua Republica houses a part of the population, and the bigger the city, the higher the rate of population growth
  - Every city also provides a small amount of jobs
  - Population in Aqua Republica consumes water, food, and energy
  - Population requires jobs and also has an affinity to good ecosystem state

- Funds
  - Funds are needed to build new structures or enforce policies within structures
  - Funds come from employed population

Cities provide a small amount of jobs
Farms provide a small amount of jobs
Industries provide a bigger amount of jobs

  - Funds can also come from trading food or energy in the market place

- Food
  - Food is needed by the population to survive
  - Food is produced from farms. In Aqua Republica, the people have no real preference in the various crops

Different crops in the farms, however, provide different amount of food, use different amount of water, and impact the environment differently

  - Food can also be purchased from the market place

- Energy
  - Energy is needed to power all the buildings in Aqua Republica, except for ecosystems
  - Energy is produced from power plants

Coal
Biofuel
Nuclear
Hydropower
Different power plants provide different amount of energy, use different amount of water for cooling, and impact the environment in different ways

- Ecosystem state
- Energy can also be purchased in the market place
  - Ecosystems require a minimum environmental flow of water
  - Ecosystems provide many different services to the catchment

- Water

  - Water is required for all structures including ecosystems to function
  - Water in Aqua Republica comes from an upstream source, local rainfall, as well as local groundwater aquifers
  - Water also flows to a downstream neighbor
  - There are only two types of water quality in Aqua Republica—clean and polluted water

Polluted water affects the productivity of all structures

The combination of the numerical model and the game layer creates a sandbox to practice making decisions. With all the underlying logic mapped out behind the scene, the player can apply theories on integrated water management, visualize consequences, and learn both by taking the right actions and by making mistakes in the game.

5 Learning Environment

Aqua Republica is a learning tool. It is not meant to simulate actual river basin management in a real catchment. However, the game can be used by players to learn about the conflicts and trade-offs that exist in a real catchment by experiencing it through meaningful play. After playing the game, players better understand the needs and perspectives of all the stakeholders involved in IWRM as well as the role and value that ecosystems perform and provide.

The focus of control of learning in Aqua Republica shifts from the teacher to the student. This helps create a more personal learning environment where players feel in control of their learning experiences. In addition to event notifications and strategy advice, a reward system is used to encourage certain behavior through positive reinforcements when the player does something right, and negative reinforcements when the player does the opposite.

The key objectives of the game are inspired by UNEP's ecosystem approach to IWRM, highlighting the importance of ecosystems and services that they provide (e.g., food security, freshwater supply, and disaster risk reduction). The game also shows that cooperation within a basin does not come automatically and needs to be both established and maintained.

Figure 5 shows the key ecosystem services that are used to inspire the game.

The current game platform is a turn-based strategy game where a player plays through 12 turns which equates to approximately 20 years. The player can spend as much time as desired before making a move and committing to it by choosing to press next turn. As such, there is no time pressure on the player to take a move, thus allowing discussions and deliberations before ending the turn and moving on to the next time step.

At the beginning of each new turn, the player will be presented with a news screen which reports on different events. These events inform the player of changes in the game environment, as a result of which actions the player took. The player can then evaluate the new state of the game and take informed actions.

The first 3 turns are part of a tutorial phase, where information about the entire gameplay is presented. During this phase, the game informs the player on which actions are needed to fix immediate needs at the start of the game. This helps introduce the player to the interface of the game and guides the player on what possible actions to take. However, the player can choose to take other actions which may result in other consequences. After the first 3 turns have passed, the player has taken all basic actions and been able to reflect upon them.

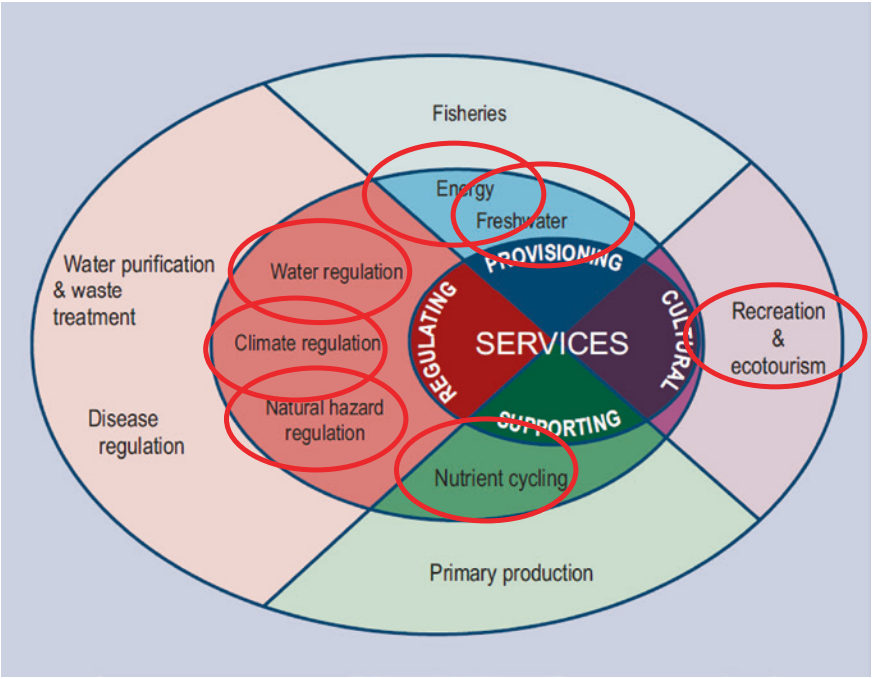

Fig. 5 Ecosystem services represented in Aqua Republica, *Source* UNEP ecosystem management program (UNEP 2012b)

Events in the game are classified into random and triggered events and are categorized as follows:

1. Tutorial events help guide the player to understand the mechanics of the game as well as the different components of the virtual world.
2. Climate- and hydrology-related events, which emulate the weather system and trans-boundary-related issues as well as disasters such as flooding and droughts.
3. Farming-related events highlight farming-related issues, such as conflicts in land use and conflicts in water allocation, pollution and so on.
4. Industry-related events highlight industry-related issues, such as conflicts in land use and conflicts in water allocation and pollution.
5. Energy-related events highlight the issues of energy, their use of water, and their impacts on the environment.
6. Ecosystem-related events are mainly events which highlight the benefits of ecosystem services.
7. Social or population-related events highlight the views of the population in the game and the issues that a city has in terms of water and the environment.
8. Economy-related events affect the economy of the game; they also include changes in the economic rules of trading and how money is earned in the game, reflecting the flux of a global market.

Fig. 6 Example scorecard and score breakdown in Aqua Republica

6 Reward and Evaluation System

Events in Aqua Republica are also an important part of evaluating a player's performance in the game. As events can be triggered by the actions of the players, actions which are in line with the principles of IWRM will trigger positive events. This rewards the player visually, as the event will encourage the player with a virtual "pat on the back"; it may also cause the game to display additional graphical rewards. The positive events moreover give extra points as well as extra funds or food in the game.

On the other hand, when the player's actions are not desirable, the game will trigger negative events. This will display events which will discourage the player to continue with the actions by penalizing the player with reprimanding tones in the events as well as deduction in scores, and resources in the game such as food, energy, funds, and state of the environment.

This means that the score at the end of the game gives an indication of how well the actions of the player are in accordance with the good water resources management. A scorecard can be used to summarize the different score components both during gameplay and at the end of the game.

As shown in Fig. 6, the score of the game can be based on a basin score consisting of the following:

- Population score shows the general well-being of the citizens of Aqua Republica. It is further broken down into 4 parts:
  - Density: The citizens will generally be contented if there is a good living space, so if population is increasing, there should be more cities in the game.
  - Job situation: The citizens will be contented if there are enough jobs in the game. Jobs are created by cities, farms, and industries.
  - Food Surplus: The citizens require food.

  - Steady power supply: The citizens also require energy.
- Production score shows the economy and food production of Aqua Republica.
- Ecosystem score shows the state of the environment of Aqua Republica. There are 2 components to this score—the rating of the ecosystem which reflects how pristine or damaged the ecosystems are and the water use in the game.
- Sustainability score shows how sustainable the developments are in the game. This is done by running the numerical model 3 time steps into the future and getting the score based on the future results.
- Achievement bonuses are extra score awarded to the player for outstanding feats of strength in the game. Some examples of achievements are Green Peace Award, which occurs when the player does not encounter any pollution event throughout the game; another example is Water Manager Award, which occurs when the player does not encounter any water shortage events in the game.

7 Gameplay and Applications

Aqua Republica is designed to be used broadly, and hence, there is no one version of the game that can fit into all the scopes of IWRM. To overcome this problem, Aqua Republica is spilt into core and unique versions.

The core version of Aqua Republica is a framework of game features and game modules which can be assembled into various unique versions. A unique version of the game can be a change of numerical model data, landscape of the game map, and having a different set of events and advice. A unique version is also more focused on a particular set of learning goals.

As noted by Egenfeldt-Nielsen (2007), "Serious games should not be seen as a standalone experience but optimally in interplay with other teaching tools. The serious games field has an even clearer rejection of the fallacy that an instructor can easily be replaced. The instructor is crucial for ensuring reflection and guidance during the learning experience. Obviously, you will still learn without an instructor, but you risk losing focus and effectiveness, as you can't replace the sensitiveness a good instructor can apply to progress learners."

There are many ways of using Aqua Republica, such as a stand-alone tool to promote IWRM or using it as a supplement to existing training programs or workshops for more focused learning and effectiveness. Depending on the uses, there are also different ways to play the game.

Table 1 lists the possible applications of Aqua Republica. Each application can be used by itself or can be used in various combinations.

For a stand-alone tool, you play the role of a water manager and you are in charge of all the developments of a part of a river basin with multiple stakeholders. Your area initially contains a river, a small urban area that includes some businesses and light industry, a few farms and a small power station. Your aim is to create prosperous living conditions for the population in a healthy and sustainably managed environment. As time moves on, drivers such as population growth, climate change, and trans-boundary developments force you to adapt to survive and thrive, for example, you may need to decide to clear a forest area to open up

Table 1 Different applications of Aqua Republica

Applications of Aqua Republica	Purpose
As a stand-alone Web-based game without any facilitators	Raise awareness of water issues Build capacity on an individual level
As part of hands-on exercises in a workshop of training course with a facilitator	Build capacity on an individual and organization level Engage participants' interest and increase discussions
As a competition between participants in a workshop or training course	Monitor and track learning progress Engage participants' interest and increase discussions
As part of evaluation in a workshop or training course with a facilitator	Monitor and track learning progress
As a tool to facilitate decision-making discussions in workshops with a facilitator	Raise awareness of water issues Build capacity on individual and organization and enabling environment level Engage participants' interest and increase discussions by visualizing consequences of various decisions

land to expand industry or an upstream neighbor uses too much water and you need to start to negotiate and react. However, developments are costly, take time to implement, use water, and impact the environment. How would you balance all the developmental needs while taking care of the environment?

Other uses of the game are only limited by your imagination; you can play with a group of people, each person representing a different stakeholder role, while one person represents the water manager that is in charge of Aqua Republica. Before deciding on which building to construct in the game, go through a series of discussions, do the actual construction in the game, and visualize the impacts. A follow-up discussion can be done after each turn to evaluate the previous decisions and discuss the next possible moves. This stimulates an actual process of IWRM.

Another way to play the game in a group is to be more open-ended, for example, if the group of participants are more homogeneous and come from one specific group of stakeholders. Before any development in the game, a discussion can be held within the group of participants; the discussion can be driven by the events from the game. In this case, when the group of participants are more inclined to farming developments, the game will present more farming-related issues and give the participants a bigger picture perspective of water and farming as well as the connectivity of other industries.

8 UNEP-DHI Eco Challenge

One example of the application of Aqua Republica is through an online gaming competition called the UNEP-DHI Eco Challenge. The competition was first held in 2013 where students from high schools (age between 13 and 16) were

encouraged to sign up to the competition. The competition was represented by 33 teams from schools in Singapore, Hong Kong, India, and Thailand.

These teams consisted of three students, and each team was accompanied by a teacher. The competition lasted for 3 days, and students were told to play the game online, and their aim was to achieve the highest score possible in the game. There were two different setups in the competition, each depending on the preference of the school. The first setup was to allow the students to play the game at their own time, and the teacher will act as a guide whenever the students needed help. The second setup was to get all the students to play the game in a common space, such as the school's computer laboratory, while the teachers function only as guides.

When the students started the competition, their scores were universally low. However, as the competition progressed and they had the opportunity to gain greater experience in playing the game, the scores achieved were progressively higher and higher.

The teams with the top ten scores were also from the second setup where the students were gathered in a common space and where the teachers were readily available to give advice on appropriate courses of action.

The increase in scores over the duration of the competition indicated that the students understood the mechanics of the game and were exploring different gameplay in an effort to maximize their scores. The game was designed such that the higher scores obtained meant a better water management has been achieved in the game. The scores achieved also showed that players had generally done well in terms of maintaining a good ecosystem state.

In order to gain a clearer picture of the educational value of the game, both teachers and students were asked to reflect on the learning experience over the three days. The reflections showed that the game and competition increased the interest of the students in topics such as water management and pollution, and as a result, they asked the teachers for more information about such topics and were generally eager to consult additional information sources such as educational books and the Internet.

The following quotes are two examples of the students' reflections:

> "The game relies on the fact of being able to manage our water resources well enough so as to able to score a high point. When I first played the game, I thought getting a score relied on the fact that by building lots of industries, we were able to obtain a really good score as more industries = more income = more points. Oh how wrong was I. After countless of tries just building industries and not realising that my ecosystem was steadily decreasing, I took some time to think about the matter and realised what I did wrong."—Matthew Tang, age 14

> "I have learnt from Aqua Republica, not only knowledge beyond our current textbook syllabus about water and land use, but also many life skills such as teamwork and perseverance. For example, we were already one day behind our competitors when we started. At that time, the highest score we could get was around 1000 points. The highest score at that time was more than 20 times more than us. There were times where I thought of giving up as I thought that getting scores like that was impossible and also as we have a limited time of 1–2 days left. But, I was resilient and did not give up; instead, I took down notes of the teachers' advices and also took down our steps to see whether there was any way to improve on it. We persevered and finally managed to find the winning solution and achieved almost the same score as the top scores."—Brian Kang, age 14

This exercise supported the notion that serious games can have a positive impact on education, especially in water, and even over a short period of three days, students have shown to be more interested in the subject and have gained knowledge through self-learning.

9 Discussions

Serious gaming in the water sector is an interesting and innovative way to enhance capacity building. Tabletop games and role-playing games have been used previously in various capacity-building exercises within the water sector (for example, the IUCN's BRIDGE project), and they have been documented to increase the engagement of participants in workshops and training courses by breaking down the barriers of communication and therefore create a better learning environment.

Digital and Web-based serious games on the other hand are a new breed of serious games in the water sector. While it is important not to be dismissive of more traditional game types, there are definitely potential comparative benefits in using digital serious games in terms of scalability, using of real-life data to create more awareness of local issues (e.g., both in terms of hydrology and in terms of people's behavior) and the ease of running the game online. Digital games with scoring and achievement components are also able to track players' progress if the games are used often enough. There is also room for better data analytics to be included in serious games for educators to better monitor the progress of students as well as for students to understand where there are gaps in their knowledge.

However, digital games may fall short when it comes to building capacity in more rural areas where Internet connectivity is low or areas where computer illiteracy is high. The approach is then to use the appropriate tools to build capacity for the appropriate target groups. It is also worthwhile to consider having both tabletop and digital games with the same learning goals and be able to choose the most appropriate tool for different circumstances and different target groups.

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