A collaborative city-based game to support soft skills development in engineering and economics

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***Abstract*— HERA is an Erasmus+ project aimed at the development of soft skills in higher education engineering and economics students through collaborative serious games. It proposes a digital learning game platform whose goal is to expose students to complex challenges, the solution to which requires integration of knowledge from diverse fields in a manner that simulates how engineering and economics professionals work and collaborate in the real world. The platform shows the typical landscape of a virtual city game, like SimCity, where it is possible to perform different actions to develop a city in an appropriate and suitable way. Available scenarios involve problems related to sustainable mobility, smart parking solutions, circular economy related to recycling, flood management, e-commerce development, Olympic Games management and even COVID. Gamifying the problem-solving process will promote active student engagement in learning through a sense of mission, a sense of affiliation, healthy competition, rewards, and social recognition by peers among other mechanisms.**

Keywords— Soft Skills, Game-based learning, Simulations

I. Introduction

21st century societies have to face complex challenges: responsible natural resource management, mitigating climate change, addressing natural risks, fighting poverty, informing global health, etc. These challenges require solutions that weave skills and knowledge from diverse subject areas and sectors towards introducing integrated, viable, and sustainable solutions [1]. Solutions to these challenges do not stem from the deployment of knowledge from a specific area, but they require the integration of knowledge from diverse fields. In a broad sense, solutions to many of these challenges are rooted in a combination of engineering and economic principles. Therefore, Higher Education (HE) faces the challenge of building not only the foundational knowledge of young professionals, but also the soft skills and mindsets that young adults need to become leaders and innovators in designing integrated, effective, and equitable solutions [2]. It needs to shape young adults that are problem solvers, high level and critical thinkers, innovators in the face of rapid evolution of technology and business processes, effective collaborators in multiple social contexts and large groups, and capable of learning independently throughout their lives in order to remain at the forefront of their fields.

HERA aims to achieve the above objectives by introducing an active, gamified and experiential learning approach that will challenge learners to collaborate, think entrepreneurially and weave diverse knowledge towards introducing solutions to non-trivial problems inspired by 21st century needs. Digitally enabling the problem-solving process will effectively increase class communication, knowledge exchange, peer learning, and collective skill building, contributing to the development of desirable transversal skills [3].

II. The HERA Game Plataform

HERA proposes a digital learning game platform whose goal is to expose students to complex challenges, the solution to which requires integration of knowledge from diverse fields in a manner that simulates how engineering and economics professionals work and collaborate in the real world. From the student point of view, the platform will show the typical landscape of a virtual city game, like SimCity (cf. Fig. 1), where it is possible to perform different actions to develop a city in an appropriate and suitable way. This city landscape will involve different scenarios, see Section III, each one proposing a specific challenge related to a non-trivial problem inspired by 21st century needs. To solve these challenges, players have to take different roles, representing different stakeholders with different goals, interests and resources, and

make decisions related to the design of the city, the selection of the elements to be included, the use of the budget, the satisfaction of the citizens, etc. Such roles have to be played by different students that need to collaborate with others players to advance in the game. The HERA platform provides a post-it facility and a chat to enable communication and collaboration and a project management tool to enable management and coordination. Gamification mechanisms, focused on promoting the long-term engagement of students, include: collaboration; inspiring missions; a sense of affiliation, belonging, and inclusiveness; and social recognition.

Fig. 1. A view of a city in the HERA game

The HERA game provides a scenario editor through which learning activities can be easily structured. The editor provides rich options for designing enriched scenarios involving diverse elements, such as (cf. Fig. 2):

- Terrain formatting, through which educators may change the layout of a map by adding elevations such a hills and mountains, valleys, water bodies such as lakes, vegetation, and more.
- A rich collection of buildings that support students and educators in designing a town with characteristics that support diverse educational scenarios. These include: residential buildings, including large and small apartment complexes, houses, houses with garages, and more; commercial buildings, such as shopping malls, fresh markets, barber shops, coffee shops, general shops, office buildings, and more; and service buildings, such as police stations, fire stations, schools, hospitals, airports, and more.
- A rich collection of city infrastructures, such as: energy productions infrastructures, such as coal powerplants, nuclear powerplants, solar powerplants, wind powerplants, transformers, and power cables; communications structures, such as internet service providers, antennas, fiber cables, DLS cables, and more; cultural and athletic infrastructures, such as stadiums and museums.
- Other structures, such as parking lots, city decorations, such as festive lights, fireworks, and Christmas markets.

The game also implements traffic, including a rich collection of utility vehicles, such as police vehicles, ambulances, buses, firefighting and trucks. Traffic can't be controlled directly by the players, but it is affected by the road layout, the parking space, the public transportation network, the weather, etc. Speaking about weather, it is also present in the game, alongside with day/night cycles and seasons, all of them affecting the evolution of the scenario while played. Time, with alterations between day and night through which the town changes, shadows are cast, city lights are lit, and more.

Fig. 2. Map tools menu. From left to right: bulldoze, terraforming, housing, industry (selected), commerce, public services, culture, infrastructure, layers

III. SCENARIOS

Scenarios in the HERA game have 2 main components: the city, where the players will play, and the scenario description, where a challenging problem and the corresponding learning activity are defined. At first, creating a scenario can be as simple or complex as the city or town you want to create. Due to the game mechanics, the buildings need to be connected with the rest of the city by roads, electric power lines, etc., just as a real city, in order to be able to mimic real problems.

When creating a city, teachers can start from a public scenario, which has a fully functional city already created, as the foundation for their own scenario. This way, it's easier and faster to create a new learning activity as they don't need to build an entire city from scratch.

Teachers don't have in-game time or budget restrictions to modify any existing city in a scenario. The idea behind this is that scenario creators can generate a city that is suitable for the problem they are going to present, so it provides a suitable context with different viable solutions. At the same time, the city also has an influence on the difficulty of the scenario.

The real complexity for the players relies on how the scenario is described, specifically how the tasks and capabilities of the roles are distributed (cf. Fig. 3). The scenario description includes the main goal and tasks for the team, a description of each player's role with individual goals, capabilities and restrictions. This last part determines how the players will deal with their tasks as a team.

Next subsections introduce some of the scenarios already developed in the project.

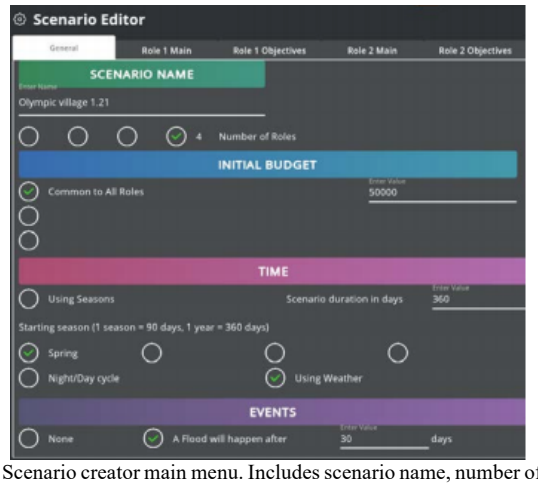

Fig. 3. Scenario creator main menu. Includes scenario name, number of roles, budget, time variables and events.

A. *The Olympic Games Scenario*

The game is situated in the context of a city intended to develop a new Olympic Village to host the upcoming Olympic Games. The players are responsible for building the needed sports facilities, infrastructure and accommodation for the event, cf. Fig. 4. The new area should also have commercial areas, public services and everything needed to make it functional and enjoyable. This is also an opportunity to improve other aspects of the city that the students may consider if they manage to fit it in the budget, like pollution control, public services coverage, overall happiness, etc.

Fig. 4. A view of the Olympic Games scenario

The solution can be approached in different ways, since they can create a separate village connected to the existing city or they can integrate the new elements in the city taking advantage of some of the existing assets.

Four roles are foreseen that students will play simultaneously, each one with its own objectives to fulfill and its own capabilities. The four roles are (cf. Fig. 5):

- Role 1: a private builder, who is responsible for the construction of 5 stadiums, accommodation for 1200 athletes and 800 visitors, and culture offerings in the Olympic village. This role can build and bulldoze housing and culture/sports.
- Role 2: a public builder, who is responsible for the construction of public roads, transportation and public services in the Olympic Village. Any terraforming needed must be done by the public builder. The public builder can also support the pollution control manager with this task. This role can build and bulldoze infrastructure and public services.

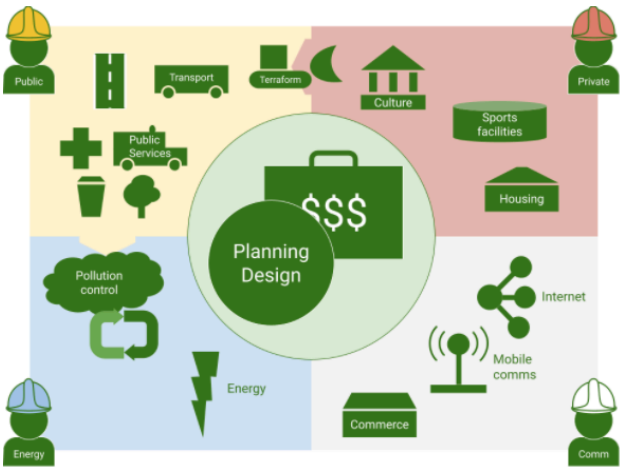

Fig. 5. Roles and dependencies in the Olympic Games scenario

- Role 3: a communications and commerce manager, who is responsible for providing internet and phone coverage to the Olympic Village, fixing any possible problems with those in the city and building new commercial establishments. This role can build and bulldoze commerce and infrastructure.
- Role 4: an energy and pollution manager, who is responsible for providing a clean and affordable energy solution for the new Olympic Village, while keeping pollution in line and reducing it if possible. Pollution control task can be supported by the public builder.

B. *Smart Parking in the City Scenario*

With technology it is possible to create a smart sensor, internet-based system in the city to optimize the search time for parking and direct cars towards nearest available parking facilities, called smart parking, the parking problem can be diminished and herby the CO2 emissions. However, the establishment of the smart sensor internet infrastructure comes with a cost as do the establishment of parking facilities.

The smart sensor internet infrastructure must be built to fit the roads and the parking facilities and therefore, there must be internet coverage in the city so that the smart parking system works. The parking facilities need to be established in a city where there probably not are many vacant spots in the city centre for the smart parking facility, cf. Fig. 6. Therefore, a negotiation needs to take place among the stakeholders of the city in relation to whether it is best to tear down existing buildings to build smart parking spaces or to live with the traffic. Additionally, some inhabitants of the city do not favor the idea of having cars in the city center and will therefore will possibly argue against the idea of smart parking.

Fig. 6. A view of the Smart Parking in the City scenario. Parks, museums and sports facilities increase happiness in the city

Following are some suggestions for roles that students may undertake:

- Role 1: The maire of the city. This role can give permission to build internet infrastructure, establish smart parking lots, build building and tear down existing buildings. Also, the maire is a person in the city that needs to make all inhabitants happy. The maire therefore, must keep an eye on creating happiness for inhabitants and car owners, but also to lower pollution, and keeping the city's money at a good, sound level. The maire must work to establish compromises amongst the other roles of the scenario game. The maire has many interests: to increase

happiness in the city, to increase the revenue of the city, and to reduce air pollution in the city.

- Role 2: The internet service provider. This role has an interest in building as much internet infrastructure in the city as possible and best so that the city is with 100% coverage. The internet service provider can build ISP buildings to ensure the internet infrastructure but at the same time this role needs permission by the maire of the city, and needs money to establish the ISP buildings. The internet service provider additionally needs to talk with the parking contractor to figure out where to prioritize the ISP buildings and internet coverage first. The internet service provider has an interest in establishing internet in the city but also to increase the revenue of the role.
- Role 3: The parking contractor. This role has a commercial interest in establishing smart parking lots. The parking contractor an only establish smart parking lots with a permission from the maire to tear down or establish the smart parking facilities. Additionally, this role needs to agree with the internet service provider where the internet must have best coverage to support the smart parking. The parking contractor can tear down existing buildings, and establish a smart parking facility in agreement with the internet service provider. The parking contractor has an interest in establishing smart parking in the city and in that way reduce traffic in the city center (which is a special traffic focused area in the game), but also this role wants to increase the revenue.
- Role 4: The lobbyist. This role is both an inhabitant of the city as well as an lobbyist that has a saying in the city administration. The lobbyist does not like cars in the city center has an overall goal to reduce pollution as well as traffic in the city center. The lobbyist will not be fond of tearing down buildings to establish more parking in the city center and will work against that and for more public transport. The lobbyist works to create impact on the maire to give fewer or less admissions to tear down buildings and approve the smart parking (which will not prevent cars in the city center). The lobbyist has a goal to be happy, and to have less pollution in the city center and less traffic.

C. *The Strategic Flood Master Plan Scenario*

It is widely recognized that dealing with large amounts of water and avoiding floods is impossible and too expensive through enlarging the sewage system or building dams and concrete channels for redirecting the natural flow paths of the water. There are several uncertainties in climate projections, but the overall pattern indicates the growing risks for extreme events. Extreme weather events cannot be managed by conventional pipe systems and their occurrence becomes more difficult to predict. Eliminating all flooding is not a realistic objective; however, the consequences may be reduced and the risks lowered for property damage and public health. Government policy has a strong role to play in increasing the amount and pace of eco-innovation in urban water delivery that is critical to the improved management of urban water. Strict environmental and economic regulations, constantly growing cities, and the general need for adaptation to climate change put pressure on utilities to find new ways to optimize the water and sewer systems. Integrated urban water management is the key element to reduce adverse impacts on surface waters and minimize future investment costs. Cities can contribute to water resources management and ecosystems and biodiversity conservation, through their design and making their infrastructure more ecological with the help of nature-based solutions.

The following roles may be used for exposing students to the scenario (cf. Fig. 7):

- Role 1: Flood prevention designer. This individual is responsible for designing the city fortifications against flooding. This may include implementing projects that alter the landscape to allow water to flow through the city without causing damage.
- Role 2: Financial controller. This individual will manage the overall budget of the city in relation to flood protection and other services and decides on the allocation of resources based on the suggestions of the flood prevention designer.
- Role 3: Fresh and waste water manager. This individual is responsible for designing solutions that ensure that water has the desired quality and is free of contaminants. In addition, she designs solutions for waste water management.
- Role 4: City inhabitants. They are interested in safety against flooding, the availability of freshwater, and quality of life.

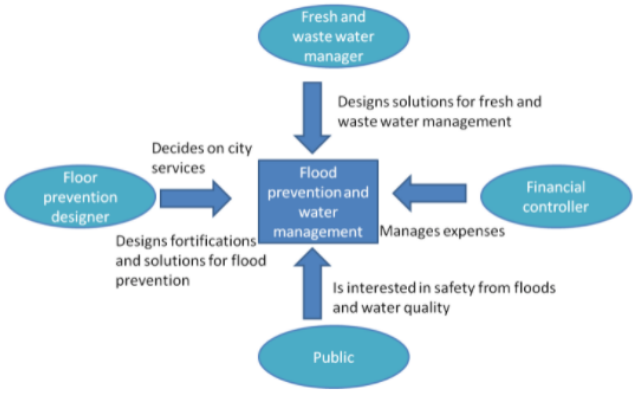

Fig. 7. Roles and activities of the Strategic Flood Master Plan scenario

IV. Conclusions and Future Work

The HERA game challenges students to solve realistic, non-trivial problems inspired by real-life. It livens up the classroom, promotes learner engagement, enriches interaction, and encourages experimentation, while putting students' soft skills to good use. Next activities in the project involve the validation of the game and scenarios with real students

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