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Intellectual Output 4. Good practice guidelines on the deployment of HERA active, game-based learning digitally enabled methodologies and tools in higher education

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1 Introduction

HERA's evaluation strategy describes the approach for **measuring the results of the project** considering its goals and **developing feedback** directly from the field. This feedback has been exploited for both **informing the design and implementation of the HERA outcomes**, as well for **documenting positive reactions, challenges faced, knowledge developed** on the best deployment of HERA outputs in real-life contexts. The final purpose of this evaluation is to ensure maximum impact and benefit for target users.

Evaluation activities have spanned the project implementation period. These activities started with the beginning of the project, in the fall 2019, and were extended along the whole duration of the project to inform the design and implementation of alpha and beta versions of HERA methodologies and tools. The evaluation was intended to ensure that the results were designed and implemented based on actual needs of stakeholders and that they were well-adapted to specific needs of different higher education organizations in terms of addressing specific learning objectives, of being easily integrated into diverse educational environments, and on having the capacity to effectively enrich educational experiences.

This report documents the HERA evaluation results as a scientific report focused on the final versions of the outcomes and good practice guidelines for maximizing the positive impact of the HERA learning intervention based on the input generated by students and educators in pilot activities that took place in real classrooms. The on-going evaluation process has allowed the integration of feedback into the design and implementation of outputs. The integration of input from diverse educational activities that took place in diverse cultural and economic environments throughout Europe ensures that the educational services to be implemented have a European dimension.

This document is structured as follows:

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- Next section 2 introduces the evaluation strategy that was designed and elaborated during the first year of the project and published as part of the intermediate project reports as T4.1 HERA Evaluation Strategy.
- Then, section 3 describes the different evaluation activities performed in accordance with the stablished strategy and the results obtained. This includes focus groups and interviews carried out at the different countries by the project partners.
- Finally, section 4 includes good practice guidelines elicited at the light of the evaluation strategies and experiences. These guidelines are focused on supporting teachers of the use of HERA outcomes on their settings.

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2 Evaluation Strategy

This section describes the evaluation strategy that has been developed early on the project. It shows the formative vs. summative approach for developing feedback and for documenting good practice guidelines for maximizing the added value from the deployment of HERA results. It further establishes specific qualitative and quantitative indicators for measuring the results of the evaluation process with the objective of developing meaningful good practice guidelines for HERA output adoption by external parties.

2.1 Project goals

The HERA project aims to:

- Expose higher education students to complex problems the solution to which requires the integration of interdisciplinary knowledge in engineering and economics in a manner that emulates real-world problem-solving processes in the industry and society.
- Build high order thinking skills such as non-routine problem solving, communication, independent learning capacity, innovative thinking, evaluation of information stemming from diverse sources, ability to integrate diverse knowledge, ability to present solutions, and more.
- Build young adults that have the potential to be innovators, pursued by challenging learners to collaborate, think entrepreneurially, and weave diverse knowledge towards introducing solutions to non-trivial problems inspired by 21st century needs. At the same time, increase class communication, knowledge exchange, peer learning, and collective skill building contributing to the development of desirable transversal skills.
- 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.

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- Empower educators to integrate the proposed active, game-based learning interventions into classrooms through good practice guidelines thus enriching existing practices and promoting career satisfaction.

1.1 PROJECT OUTCOMES

The evaluation process targets all project outcomes, including:

- **O1: educational approaches**, and specifically the HERA active, game-based learning framework for building multidisciplinary engineering and economics skills for the 21st century with applications to the real world.
- **O2: software services and tools**, and specifically the HERA educational game-based platform and learning scenarios that with help develop problem solving capacity.
- **O3: instructor support content** that contributes to the effective integration of proposed learning methodologies and proof of concept digital tools into existing educational practices.

2.2 Target groups

The HERA project directly targets 2 groups in the higher education area:

- **Students**, who stand to gain from their engagement in innovative, active based educational design, that helps build engineering and economics skills that are transferable to the real world. Students are the beneficiaries of innovative educational design based on game approaches that promote engagement in the learning process, contribute to knowledge scaffolding through meaningful feedback on learner actions that help them understand the links between decisions and outcomes, and promote soft 21st century skills that include critical and analytical thinking, ability to collaborate in multidisciplinary and potentially cross border teams, capacity for independent learning, and more.
- **Educators**, who stand to gain from developing their skills in structuring and delivering active learning educational activities that take advantage of serious games and

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simulations to promote engagement, interaction, and active learning into classrooms. Educators are the end users of training content in the form of learning sheets, videos, and reference guides that is designed specifically for them and aims to build their abilities to integrate emerging pedagogy and technology.

Additional groups can benefit indirectly from the HERA activities. These include educational organizations, educational policy makers, the academic community that focuses on lifelong learning, the educational software industry, and the general public.

For a detailed analysis on the skill development needs of direct stakeholders please refer to intellectual output O1, the HERA methodological learning framework (HERA Educational Requirements and Methodologies, 2020).

2.3 Evaluation objectives

HERA evaluation aims to measure the benefits of the proposed game-based, explorative learning approach towards building multidisciplinary skills and problem-solving capacity among engineering and economics students.

More specifically, evaluation aims to assess:

- **EO.1: Ease of use** of project results for both students and educators**.**
- **EO.2: Acceptance** of HERA methodologies and tools by students and educators.
- **EO.3: Relevance** of HERA methodologies and tools in engineering and economics HE.
- **EO.4: Effectiveness** of project outcomes towards building soft skills. Namely, to develop well rounded young adults that have the capacity to address 21st century challenges through engineering and economics solutions.
- **EO.5: Ease of integration** of project results from a pedagogical point of view.

These goals influenced the evaluation models designed and deployed in HERA. An analysis of the broadly accepted evaluation methods and their deployment in HERA follows.

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2.4 Assessment approaches: formative and summative

HERA's evaluation strategy is organized into two high level activities: generation of user feedback through "formative" approaches and generation of good practice guidelines through "summative" approaches.

Formative approaches (SchildKamp et. al, 2020) aim to generate on-going feedback to inform the design and implementation of a service along the project development. Formative evaluation is applied in an iterative manner and aims to enrich outcomes of a specific project. Each iteration produces feedback that can inform the design and development of a product. The main idea is to ensure that the design and implementation of the project outcomes takes user needs into account. Formative evaluation started being applied early in the project implementation period during the design of the proposed learning methodologies and supporting digital services. Early versions of outcomes have been tested with external users to document the positive elements of the implementation and to identify areas of improvement in a manner that leads to the optimization of project results. To support this approach, we applied both qualitative and quantitative models: survey, interviews, and focus groups.

Summative approaches (Kibble, 2017) (States, 2018) take place upon completion of an activity and aim to assess the degree to which outcomes reach objectives. Summative approaches were deployed in the second half of the project implementation period to identify good practice guidelines coming from the experiences performed in the second half of the project implementation, involving students and educators. Summative evaluation aimed to capture the most appropriate approaches and scenarios to use the HERA framework, platform, games, and resources to be used for the training of higher order thinking skills. Issues such as the number of students involved, the composition of students' teams, the timing of the experience or the phases have been considered. Formative approaches also apply both qualitative and quantitative models: questionnaire, interviews, and focus groups.

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2.5 Assessment models: qualitative and quantitative

2.5.1 Qualitative indicators

Qualitative models (Aspers & Corte, 2019) for evaluation are useful when the answers to evaluation activities must be documented in a descriptive, rather than numerical, manner. Results are documented as views, attitudes, perceptions, or opinions in a narrative manner, for example through texts, interviews, or narratives. The advantage of qualitative models is that they involve human interaction and interpretation, which may particularly be useful depending on the evaluation context.

The evaluation objectives of HERA, which involve the establishment of the relevance, acceptance, quality, and effectiveness of project outcomes, can benefit from qualitative approaches which are more suitable in documenting perceptions and attitudes. For this reason, qualitative models have been at the core of the HERA evaluation activities.

Qualitative indicators are used to measure the achievement of the following evaluation objectives:

- **EO.1: Ease of use** of project results.
    - **Qualitative indicator**. Student and educator response to piloting activities during which the tools have been deployed.
- **EO.2: Acceptance of HERA methodologies** and tools by students and educators.
    - **Qualitative indicator**. Participant comments and their **eagerness to use the tools** in learning contexts.
- **EO.3: Relevance of project outcomes** as tools for enriching higher education engineering and economics educational experiences and for building skills demanded by the industry.
    - **Qualitative indicator**. Student **engagement levels** in piloting activities.
- **EO.4: Effectiveness of the project** methodologies and tools in achieving the project goals.

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- **Qualitative indicator**. The perceived **added value** of HERA outcomes among students and educators.

- **EO.5: Ease of integration** of project results into existing educational practices.
  - **Qualitative indicator**. Instructor willingness to update their instructional practices through the HERA proposed learning intervention.

2.5.2 Quantitative indicators

Quantitative models (Eyisi, 2016) are deployed when the outcomes of an evaluation activity are best documented statistically or through numbers. Evaluation outcomes can be measured through scientific tools or models. In quantitative evaluation, individuals performing the same work independently should reach the same results. The benefits of quantitative models revolve around the objectiveness and accuracy that stems from statistical analysis. However, they are not always applicable, for example they cannot effectively document perceptions and views.

Quantitative evaluation in HERA aims to explore the **level of engagement** of participants, in terms of actual numbers reached in the context of learning experiments. The following **quantitative indicators** are proposed to document engagement levels of students and instructors with HERA activities:

- Number of learning experiments organized.
- Number of students involved in learning experiments.
- Number of educators involved in learning experiments.
- Number of focus groups (around 5 students involved per session).

The combination of qualitative and quantitative models in HERA evaluation provides complementary information that is be complete, objective, and rich allowing the drawing of conclusions in relation to best practices on the use of project outcomes for achieving problem solving skill building in engineering and economics HE.

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Quantitative indicators are used to measure the achievement of the following evaluation objectives:

- **EO.1: Ease of use** of project results.
    - **Quantitative indicator**. Usability and user experience (UX).
- **EO.3: Relevance of project** outcomes as tools for enriching higher education engineering and economics educational experiences and for building skills demanded by the industry.
    - **Quantitative indicator**. Engagement.
- **EO.4: Effectiveness of the project** methodologies and tools in achieving the project goals.
    - **Quantitative indicator**. Learning and pedagogical aspects.

2.6 Evaluation activities

Evaluation activities have been organized in the form of learning experiments and reviews.

The learning experiment concept is a term that is deployed in research literature and points to actual engagement of stakeholders in the context of real-life educational activities (Dearborn, 1910) and the documentation of their reactions, feelings, achievements, perceptions, and attitudes. Using learning experiments allowed the benchmarking of project outcomes in real-life conditions and the generation of feedback from their deployment in actual educational contexts, thus ensuring that feedback is relevant and objective.

During the learning experiments, higher education students have:

- Been informed about the HERA project, its objectives, and activities.
- Used the HERA learning that is implemented in the form of educational games.
- Communicated their experiences and suggest enhancements in the context of debriefing activities.

Learning experiment feedback documented information on the analysis and assessment of the outcomes by students and experts considering the entire process of digitally enabled

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learning process design: methodological design, software design, software implementation, educational process design, etc. The main purpose of these reviews was to generate feedback in a formative manner to inform the development of the project outcomes. These activities have been implemented at two levels: external and internal.

Learning experiments have been carried out by external groups representative of the target higher education sector, namely educators and students, in all countries in which the consortium has project partners. More specifically, the original evaluation objective documented in the project proposal was to organize validation activities at 5 piloting sites engaging 50 higher education students and educators at each. The foreseen evaluation sites were:

- The University of Thessaly (Greece).
- Tallinn University (Estonia).
- Porto Polytechnic (Portugal).
- University of Vigo (Spain).
- Aalborg University (Denmark).

Notably, as will become evident from the discussion of evaluation outcomes below the number of participants at each evaluation site significantly exceeded proposal objectives.

Some **reviews were performed by external groups**. Particularly these have been used to get feedback from alpha and beta versions of the project outcomes during its ongoing development.

In addition, other **review activities were performed internally among the project partners**. These were performed during the project meetings at the end of the first year and in the middle of the second year. During these reviews the project partners provided feedback on the outcomes produced.

2.7 Evaluation tools

The following tools were deployed in HERA evaluation (see Appendix):

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- **Focus groups**. Focus groups (Freitas et. al, 1998) involved group interviews that aimed to establish attitudes of individuals. As their name suggests, they aimed to introduce focus, to highlight, and to bring forward key issues that concern a particular group. Focus groups in HERA aimed to qualitatively assess the benefits of the proposed game-based intervention on building problem-based learning skills for the 21st century. Two different focus groups were considered:
    - **Students participating in the learning experiments**, who provided feedback documenting their learning experiences.
    - **Students participating in reviews**.
- **Interviews**. Interviews (Shazia, 2014) are a fundamental tool of both qualitative and quantitative evaluation models. They involve the interviewer, who seeks information, and the interviewee, who provides it. Interviews can be used for collecting both descriptive and statistical information for understanding the respondent's attitudes, perceptions, and opinions. Two different interview types were considered:
    - **Educators participating in the learning experiments**, who described their experiences from the deployment of the HERA methodologies and tools in their classrooms. Student feedback was generated through either interviews or questionnaires.
    - **Educators participating in reviews**.
- **Evaluation questionnaire.** This questionnaire focused on the evaluation of the experience and usefulness of HERA's serious game. For that, user experience and engagement are key elements. Besides these, the questionnaires aimed to measure the perceived usefulness of the experience in terms of learning and pedagogical value. A specific questionnaire of 3 sections of 8 items each (see Appendix) was developed based on existing evaluation methods for documenting user experience (UEQ) (Hinderks, 2020) and engagement (GenQ). The questionnaire further included 8 custom items for documenting learning and pedagogical aspects. Finally, 5 open

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ended questions were included in the questionnaire to register suggestions, likes, and dislikes. The estimated time to complete the evaluation was less than 5 minutes.

The exact combination of the tools has been adapted to the needs of each evaluation site in a manner that supports existing educational practices, provides the desired feedback, and is not intrusive in the learning process. In this way, the evaluation practices have been performed in a different way at each evaluation site, in some sites carrying out learning experiments and reviews in advance to have formative evaluations for the improvement of the project outputs, while in others as final summative evaluations of the project results.

Similarly, focus groups and interviews were considered in a flexible way. Both instruments are very similar, and partners were free to use either focus groups or interviews as they considered fit.

2.8 Evaluation agenda

The agenda of the HERA evaluation activities involved the following plan:

Evaluation of alpha and beta versions:

- **Evaluation activities**: Reviews.
- **Purpose and focus:** This activity enabled to ensure that the project outcomes were designed and implemented based on actual needs of stakeholders and that they were well adaptable to specific needs of different higher education organizations in terms of addressing specific learning objectives, of being easily integrated into diverse educational environments, and on having the capacity to effectively enrich educational experiences.
- **Timeframe**: Fall 2020.
- **Number of students involved**: Engagement of 10 students per country.
- **Disciplines**: Engineering, economics.
- **Tools used**: Focus groups and interviews.

Evaluation of final outcomes:

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- **Evaluation activities**: Learning experiments.
- **Purpose and focus**: This evaluation was focused on:
    - The acceptance of HERA methodologies and tools.
    - The perceived relevance of project outcomes.
    - The perceived effectiveness of the HERA methodologies and tools in achieving the project goals.
    - The ease of use of project results.
    - The ease of integration of project results into existing educational practices.
- **Timeframe**: Winter 2020 and spring 2021.
- **Participants**: Engagement of 50 students per country.
- **Disciplines**: Engineering, economics.
- **Tools to be used**: Focus groups, interviews, and questionnaires.

In some sites, such as Greece and Spain, evaluation activities took place earlier in the project implementation period to gather ideas and opinions from students and educators. This involved the performance of reviews in which participants were introduced to the project goals and were invited to propose ideas for game scenarios involving problems of interest for engineering and economics.

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3 Evaluation activities and results

This section presents evaluation activities that took place at each foreseen piloting site in Greece, Portugal, Estonia, Spain, and Denmark and summarizes evaluation results.

First, it is important to notice all partners have many difficulties to carry out the evaluation activities in accordance with the planned schedule because the COVID-19 pandemic situation. Plans had to be continually adapted and modified accordingly to the changes in restrictions in each country. In many cases, learning experiments were performed remotely; focus groups and interviews were mainly performed in face-to-face settings. Despite some difficulties to perform the learning experiments online the use of videoconferencing tools enabled the experimentation to a great extent.

Quantitative values of the evaluation are shown in Table 1.

	Greece	Estonia	Portugal	Spain	Denmark
Learning experiments	1	1	1	1	2
Students involved	120	35	65	86	50
Educators involved	1	3	3	7	4
Focus groups & Interviews	24	8	2	4	10

Table 1. Summary of quantitative evaluation results.

3.1 Evaluation site in Greece

Evaluation activities in Greece took place at the University of Thessaly (UTH). The University is the only higher education institution in central Greece and more specifically in the geographical area of Thessaly. The organization has emerged from the merging of 3 higher education institutions in central Greece, becoming the 3rd largest university in the country. The University has 37 departments geographically spread in the towns of Volos, Larissa, Karditsa, Trikala, and Lamia. It enrols 40.000 students at the undergraduate and graduate level.

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The main evaluation site was the Department of Electrical and Computer Engineering. The department organizationally belongs to the School of Engineering. It enrols 1.000 students and has a faculty of 25 instructors.

Evaluation activities took place in the context of formal courses in the undergraduate and graduate programs. Following is a description of the groups that have participated in evaluation and the performed activities.

3.1.1 Evaluation activities

Activities took place in the context of the Technology in Education course. The course is an elective in the 5th semester of the undergraduate curriculum. It is typically attended by 140 students each year. The course focuses on the deployment of technology as an educational tool in lifelong learning contexts that target the needs of diverse groups including school learners, higher education students, adult learners, vocational learners, professionals, and others. It also analyses traditional and modern learning methodologies such as learning through problem solving, collaborative learning, learning with action, experiential learning, game-based learning, and more.

Students were already engaged with HERA activities. In the fall 2019 semester students were involved in a review suggesting overviews of potential scenarios to be fully developed and integrated into the HERA digital learning game for active learning. Approximately 140 students engaged in this activity. At that time, the students introduced 24 non-trivial scenarios the solution to which requires the integration of knowledge from diverse thematic areas in the curriculum. Examples of suggested scenarios include:

- Design of infrastructure for a fast, fibre-optic internet service for a city.
- Design of a green city.
- Planning for energy independence of public buildings.
- Protecting a city from earthquakes.
- Design of a car-pooling service for a city.

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- Design of a simulation services for the medical sector.
- Design of an electrical circuit simulator.
- Providing adequate water and energy resources to islands communities.
- Protecting a city from floods.
- Designing a fault tolerant energy system.
- Designing a traffic monitoring service.
- Protecting a city from fire.
- Designing a mobile network.
- And more …

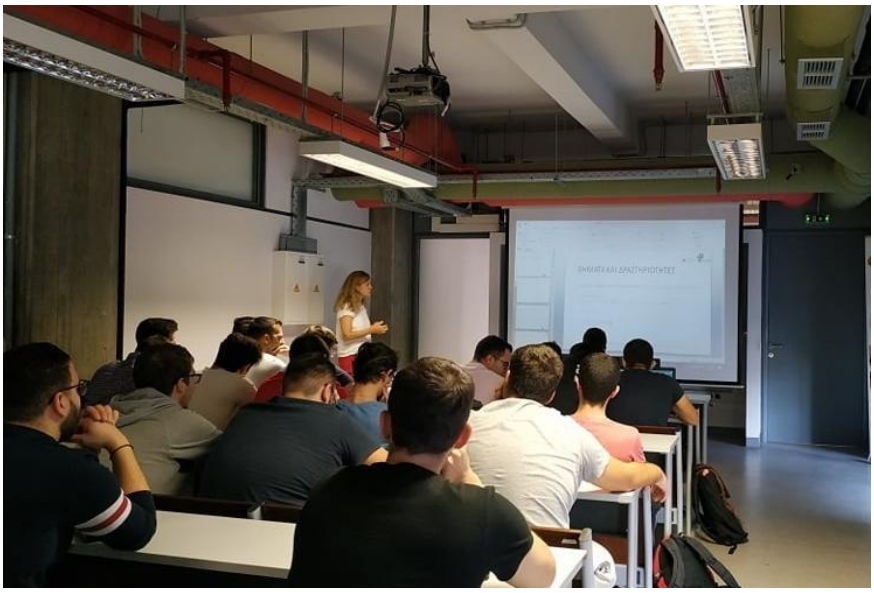

Figure 1. Students in the Technology in Education course of the University of Thessaly attend a HERA presentation

Students voted on their preferred scenario, with the winning team receiving a symbolic prize.

Student engagement continued in the fall-winter 2020 semester. At that time, students were actively engaged in the review and piloting (learning experiment) of the digital learning game. During the piloting activities students used the learning game in active educational contexts to solve challenges related to their studies. They worked in groups of 4 - 6 individuals creating new scenarios and testing the functionality of the game. A total of 24

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teams were created. Approximately 120 students were engaged in this activity. Notably this group was separate from the one that engaged in 2019. The total number of students that engaged with the HERA game over 2 years was over 250.

Upon completing their use of the game, students participated in a review providing feedback by responding to the interview questions identified in the focus groups as well as filling in the quantitative questionnaires for documenting their experiences and suggestions for enrichment. Student feedback was integrated into the HERA learning game in the spring of 2021, ensuring that the viewpoints of the target higher education community are considered in the implementation.

3.1.2 Student focus group feedback

Following is a summary of feedback provided by the 24 focus group teams that responded to questions related to usability, technology, experience, learning, and other pedagogical issues.

3.1.2.1 Ease of use

In relation to the usability of the game, students responded on the following aspects:

Usability

Students commented that when the user starts the HERA game for the first time, whether they deploy the game as teacher or student, she can easily understand the basic functions of the application. According to student feedback, on becoming exposed to the game for the first time the user needs to spend some time becoming familiar with the game; after this the use of the game becomes quite easy. The game instruction manual and the videos that describe its functionality contribute to the understanding of the game design.

Students commented that the game is quite easy to use, as the responsibilities of each role that the player can choose are determined from the beginning. Furthermore, users can easily understand which buildings and spaces they are allowed to construct towards achieving their individual goal. Gameplay is easy, allowing the player to create their own

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content-script with several options. Moreover, the possibility of choosing 8 different languages, gives the opportunity to more people coming from different countries to collaborate and use the game.

Understanding the game functionality

Students commented that the game, its vivid graphical interface, and the descriptions of activities published in its environment make it easy to engage in learning and allow the user to build familiarity with the game quickly. In addition, the game is customizable allowing educators to not only use the existing scenarios but also create their own for addressing specific needs of their class. From the teacher's point of view, creating a new scenario is a simple process, as there are specific steps that need to be followed. On the other hand, students can choose from a wide variety of scenarios and roles for improving a broad range of skills.

More specifically, the goals of each player role in the game are clear. Similarly, the use of each building block is well understood through the provided descriptions. The game auxiliary menu allows users to clearly distinguish each layer of information in the city, such as health, culture, infrastructures, and more.

Students suggested that some additional functions which would be helpful would be to ‘be given tips’ while creating or working on a scenario and having an ‘undo’ and ‘refresh’ button when editing the city map.

Compatibility of the gameplay

Students commented that the gameplay is straightforward. What makes scenarios challenging is the fact that students need to work together as a team to come up with an efficient solution to the given problem. The scenarios and the game functionality are designed in a manner that does not allow an individual student to complete all tasks. This demonstrates the need to work in groups of individuals with complementary skills in a manner that simulates real life. The overall goals of a learning scenario may be simple, but it is important to discuss ideas with group members to effectively address it.

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The construction of a city is easily executed. The buttons of the interface provide all the information that a user needs for deploying them. With a few clicks, the user can build the city she has envisioned. The time required for someone to get acquainted with the gameplay is estimated to just a few minutes.

The game simulates in a comprehensible way the corresponding realistic scenarios of the real world. Moreover, it does not require specialized knowledge, but rather the use of common sense and critical thinking. At the same time there is the possibility of monitoring game progress in relation to the goals set, giving the user a sense of achievement.

3.1.2.2 Acceptance

User-friendliness of the application interface

Students commented that the user interface of the game is quite simple, and this makes it accessible to all, including experienced and non-experienced users. The 3D graphics make the game more attractive. All game elements are organized into categories and are easy to find and use. The user immediately understands the game operation and can start to use it with little effort due to the resources and features provided. Simply, the user can login into the game with his account or create a new account if he does not have one; then he can start working on an existing scenario or build a new one.

The game buttons are place in well-selected locations on the screen and are accompanied by well-understood instructions. The videos on the game functionality significantly help the user become acquainted with the gameplay; they provide all the information that someone may need for getting started on solving problems in the HERA environment.

The game clearly identifies 2 separate core roles: one for scenario creation, used by content creators such as educators, students, or other stakeholders, and one for playing an existing scenario, used by content consumers, such as students. In each case, the game provides a set of straightforward options presented in an easy-to-use menu, making the use of the game quite easy and understandable.

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The game already includes a series of problems that the player can choose from to engage. Problems are open ended, allowing users to introduce different solutions thus building critical thinking.

Suggested game improvements

The students suggested an easier way to move on the game map, for example by using the mouse. Notably, the game already offers this functionality, as well as the option of moving around using keys well-known to individuals that engage in digital gameplay.

In addition, the game could provide ready-made city plans. This has been addressed already through the creation of small, medium, and large sized cities that the user can edit.

Students also suggested the integration of a tutorial, which is addressed through the videos that demonstrate the game functionality.

Students suggested additional city building features, such as other means of transport, for example bicycles, that could contribute to the reduction of pollution.

The game offers day and night cycles that make scenarios realistic. Students suggested that during the night mode users could add lighting, which could allow them to better work in the dark. This has been integrated into the game in the form of higher night visibility.

Students also suggested the creation of human characters for each role. Thus, the user, in addition to adopting a role, would be able to identify with the role as an entity. In this way one could give the impression of a game that represents the life of a city that through the movement of citizens in the streets and other aspects of daily life that would make the game even more attractive. This feature was not implemented as it is beyond the scope of the project. The game's first-person camera model allows users to have direct view of the city they create.

Finally, the students suggested that the game could provide a view of teammates connected to the game, so that a user can be aware of others working simultaneously and exchange

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ideas. This is partly implemented through the chat in-game communication feature (see below).

Ease of collaboration

The in-game collaboration features between the players, such as the in-game chat, is very constructive, contributes to teamwork, and encourages the exchange of ideas.

3.1.2.3 Relevance

Interest level of the game

The HERA game introduces users into a virtual world in which they solve problems that address the everyday issues in a city. Students commented that the game is very interesting, both for students, who aim to fulfil the objectives a given scenario, and for the teacher, who can use already available scenarios or be inspired to create new ones.

The game is very creative, allowing the user to practice and sharpen her thinking. This is achieved through the tools available in the game environment, the use of which can lead to the creation of both simple and complex scenarios, depending on learning objectives, with aesthetically interesting results. The game offers rich functionality, such as soil creation, weather conditions, day and night cycles, a broad range of public, industrial, and residential buildings, infrastructures, and more allowing endless combinations for creating a city tailored to the interests of the user.

On the other hand, the game allows the player to select roles to adopt depending on his interests and the skills that he wishes to develop. In addition, the game is multiplayer, allowing students to work in teams to collectively address problems related to the real world, such as designing city services address the COVID-19 pandemic, managing waste, creating an environment that fosters eCommerce, building the next cultural capital of Europe, and more. This makes the game particularly interesting for higher education, as it challenges students to collaborate and share knowledge towards designing solutions.

Suggestions on making the game more interesting

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Students suggested that the game could become even more interesting by introducing additional facilities, such as buildings and houses, for the player to use or the ability for a player to create her own buildings, putting their personal touch in the city.

Another idea would be to allow the support of more concurrent student roles in the implementation of a scenario. This is something that can be considered, although there is a limitation to the size of a team that can effectively work on-line and off-line. In most cases student teams, even off-line ones, are comprised of 4 – 6 individuals because this size allows collaboration while it also promotes the engagement of all team members. This number is comparable to what the game supports today.

Finally, students suggested the addition of a leader board, listing the teams' scores, to motivate them to perform their duties more effectively and with higher quality and motivate engagement. This is a nice idea, but it has the drawback of converting a creative, open-ended, collaborative game to a competitive one, which may not be desirable.

3.1.2.4 Effectiveness

Encouragement of learning

Students commented that HERA is a game that integrates problem-based learning into traditional education as the successful completion of a scenario requires the integration of knowledge from different thematic areas. The game scenarios encourage users to research information and apply the knowledge they develop towards designing an effective city based on scenario objectives. Using a game is one of the most effective ways of training, making learning more flexible and fun through the typical features of a game and motivating users to engage in finding solutions by overcoming difficulties and challenges.

The game is a great learning facilitator as it incorporates real-life scenarios into an easy-to-use and attractive environment, which encourages student engagement and alleviates discouragement that may result due to the complexity of the real-life problems that inspire the game scenarios. The more time a student spends on the game, the more she becomes engaged towards achieving scenario objectives.

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The game brings liveliness to the learning process, promotes interactivity and supports knowledge building in a pleasant way alleviating the pressure that may be created by traditional teaching methods. The hands-on game activities further promote the retention of knowledge and ability of students to apply it in real-life.

Collaborative activities not only give students an opportunity to become accustomed to working in teams towards solving real-life problems; they also prepare students for their transition from the academic environment to the world of work. The game activities promote constructive dialogue among team members towards addressing the challenges introduced by game scenarios.

Contribution to engineering education

Students commented that the HERA game promotes problem solving capacity among students independently of their area of study. The focus of the game on city design makes it suitable for all engineering principles.

The game would be a valuable addition to learning activities that target 1st year students in departments such as electrical engineering, mechanical engineering, civil engineering, urban planning, and more. For example, electrical engineers could be exposed to a scenario that challenges them to construct the energy network of a city. Architects and civil engineers could design and shape an entire city in the best possible and efficient way that coincides with their field of work.

The collaborative nature of the game makes it a very good candidate for engineering education, as in real-life engineering projects are typically implemented by multi-disciplinary teams. Students build knowledge by building on each other's ideas and sharing information. For example, to complete a scenario for effective city design students with diverse interests and strengths need to collaborate to ensure effective city water supply, irrigation, electricity, and other networks.

Development of problem-solving skills

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Students commented that engagement in the HERA learning game requires some previous knowledge related to scenario objectives. Through their engagement, students build additional knowledge related to the role that they adopt in the game. At the same time, they are challenged to optimize their solutions and strive to complete their work within a specific time limit. The game builds problem-solving skills as it empowers users to experiment by putting their ideas to practice in a safe, virtual environment, to review their results, and to make improvements for better addressing scenario objectives.

Finally, students commented that the game helps build student skills in addressing everyday life problems as it contributes to logical and analytical thinking, builds basic knowledge related to financial and project management, and develops understanding on how society works. This prepares students for becoming the problem solvers of tomorrow in related work environments.

3.1.2.5 Ease of integration

Courses in which the game could be used

Students commented that the HERA game could be used in a wide range of courses and departments as problem solving skills are desired by industry in the entire engineering sector and even beyond. They commented that the game is quite interesting and covers a wide range of specialties. According to student comments, the game is also relevant for individuals that are involved in civics and are interesting in making society more inclusive, initially in the game's digital environment and, later in life, in real world practical activities.

It could also be used with adaptations by secondary or higher education students for engaging in digital games that have, in addition to entertainment value, learning benefits. This would channel the energy that young individuals invest in games towards building knowledge in a fun and effective way and would attract young individuals to the engineering sector, which is desirable due to its fast growth that is expected to lead economic recovery in Greece.

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The HERA game is also interesting to students in economics, management, telecommunications, energy, and other sectors. The energy design elements of the game are particularly interesting and realistic. In addition, scenarios could be introduced for creating telephone networks that effectively span an entire city through services that have the capacity to support the city's population.

Another area where the HERA could be used is resource management. Problem-solving in scenarios requires good use of financial resources as students work within a limited budget in a manner that simulates real-world scenarios. Students learn to effectively manage their resources towards building the facilities that make city citizens happy, healthy, and safe.

Re-playability of the game

Students commented that the game has good re-playability value. Students may play the same scenario more than once as a result of the open-ended nature of the game. If students do choose to play the game a second time, they may exploit the experience they developed in the earlier engagement towards improving their work, achieving the scenario goals in a different way, or designing a more financially effective solution that still addresses the needs of city inhabitants and promotes prosperity. By re-playing the game, players can try to accomplish their goals in a more organized and efficient manner both in terms of time and financial resources. They can further correct any mistakes they may have made in their earlier engagement.

Players may also experiment with new ideas, see the results of their choices, and compare them to previous solutions. This encourages them to reflect on the concept of optimization, namely not only designing a correct solution but focusing on the best solution. They can make different choices and observe and compare changes in the outcome of the script, thus further sharpening critical thinking and problem-solving skills. In addition, playing the game again allows students to assume different roles, having a different experience and building a different set of skills. Finally, students could play the game with a different team, again diversifying their experience in the context of collaboration and building interpersonal skills.

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3.2 Evaluation site in Estonia

Tallinn University (TLU) is the 3rd largest university in Estonia and the biggest one in humanities. The university further has engineering-related curricula. In Tallinn University evaluation involved students from the following curricula:

- Computer Science, Bachelor of Arts, enrolling 241 students.
- Educational Technology, Master of Arts, enrolling 46 students.
- Management of Information Technology, Master of Arts, enrolling 70 students.
- Digital Learning Games, Master of Arts, enrolling 48 students.
- Human-Computer Interactions, Master of Arts, enrolling 39 students.
- Teacher of Computer Science, Master of Arts, enrolling 34 students.
- Applied Computer Science, Applied Higher Education, enrolling 57 students.
- Ecosystem services subject for Integrated Natural Science and Environmental Management, Bachelor of Arts, enrolling 35 students.
- The first 4 programs are part of the School of Digital technologies and specifically the applied sciences curriculum. The programs take place at the small campus in the city of Haapsalu College. The Ecosystem Services course is part of the Integrated Natural Science and Environmental management curriculum in the School of Natural Sciences.
- The educators that led the evaluation activities include Andrus Rinde, Tanel Toova, Inga Petuhhov, and Jaagup Kippar who teaches the General-Purpose Development Platforms course in spring 2021.

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Figure 2. HERA presentation to Estonian students

3.2.1 Evaluation activities

The evaluation activities took place within the Ecosystem Services subject during winter-spring of 2021. 27 students in their 2nd and 3rd year engaged in the activities. The students were working on their thesis in the same field. These students were also involved in case studies and seminars with practical field activities combined with serious gaming. Ecosystem services, as socio-economical concepts, tightly connected with the understanding of the ecosystem functions offer ample opportunities to integrate activities from different disciplines. Students learned through gaming, and specifically a board game of Ecosystem Services, and ICT solutions, and specifically http://avastusrada.ee for mapping and reviewing the ecosystem services, or lack thereof, in a city. Although students are focused mainly on their studies, given that this course combines different disciplines, it summarizes and systematizes students' previous theoretical knowledge, helping students to understand the connection between economy, social systems, and environment. The HERA game was included as part of this academic year's activities.

The HERA game was presented and explained for students during lectures. Watching the tutorial video and playing the game was homework. Students engaged with an early version of the "flood" scenario, which was created specifically for this activity. Players were also

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encouraged to discover the game options and reflect on how to implement ecosystem services concepts in the game.

3.2.2 Student focus group feedback

In general student were happy with the game and enjoyed the experience. There were some technical problems, and a few students couldn't start the game the main reason being the lack of a Windows-based computer. Those students only watched the tutorial video.

Students commented that the game has a lot of potential. Minor technical problems were discovered, which were fixed in the game as a result of the evaluation activity. Students needed some time to become familiar with the application UX.

What students liked

Many students mentioned the game playfulness, inventiveness, and endless possibilities to develop their own world. One student pointed out that the game made some complicated concepts easier to understand and to apply their knowledge into real life situations instead of having just an abstract collection of facts. An important aspect was also the educational value. Students commented that the game offers the possibility to learn in ways other than following lectures, which is considerable added value in educational contexts. Many students found that freedom in-game is very important. They commented that the player can build everything everywhere, visually design his own city, or even create his own scenarios. They liked the ability to control the game world, to modify it, and to use it towards solving problems. The sandbox element was also highlighted. Students commented that player can create his own "adventure". From course and scenario topic came the recognition that HERA follows the rules of popular city-builder games but is clearly more orientated towards environmental challenges.

What students did not like

Some technical difficulties arose during the use of the alpha and beta versions of the game. For example, some students had trouble starting the game, found the menus confusing, and

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discovered some software bugs. Some individuals were not fond of the game graphics or the sound. Student feedback was integrated into the game, especially in relation to technical problems that naturally arise when testing a software tool in the alpha or beta phase of development. Another concern was a steep learning curve and the time required to learn and play the game. One student wrote “I felt that the game was too complicated, and it was trying to overachieve. It should have started more easily to warm the player up, instead of giving too much information and taking the pleasure of playing the game away.”. Especially hard was it for those, who are not everyday gamers.

How to make it better?

Students had many of good ideas about game development and as it was early version, many of those are already implemented in later version. These include the possibility to “random” events, such as flash floods, more game settings and landscaping options, more buildings, and more. Many suggestions stemmed from the student background. Students wanted more possibilities related with nature to the game, such as abilities to introduce water bodies, forests, and more to be able to implement water-related structures and services into their solutions. Also, more “life-like" effects were asked, such as walking people and animals, not only cars, changes from day to night, smog, and changing weather conditions, for example rainy, sunny, snowy, or windy weather.

New scenario ideas

There were very different ideas about scenarios, but one common thing is to use the game for solving big world-scale problems to understand them better. Different natural disasters, fuel shortage and discovering alternative energy sources, recycling challenges, drinking water pollution, and famine are some examples of student suggestions for additional scenarios. COVID-related scenarios were also proposed, and specifically a more advanced version of the COVID-city scenario that includes additional roles different goals such as minister of public health, whose goal is to stop the pandemic, environment minister, whose goal is to stop climate change that is speeding up since the pandemic makes people use

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more single-use plastic masks and gloves, minister of the economy, whose goal is to achieve savings and invest them into the economy of the country in order to save it, and representative of tourism and entertainment, a sphere of daily-life that suffers a lot during the pandemic. In this alternative version of the scenario the focus would be the economy rather than health care.

Implementation of ecosystem services into the game

According to the course program, the last task for the students was to suggest ideas on how to implement ecosystem services concepts into the HERA game. Ecosystem services have significant effect on air filtration, microclimate regulation, noise reduction, rainwater drainage, and sewage treatment. They can be supported by the addition of trees, open land, lakes, and other formations. They can filter the city water supplies, hold the ground in place to avoid erosion, protect shorelines, help retain natural sediments, attenuate wave energy, and more. Ecosystem services can play a key role in natural disaster prevention or recovery, for example protection from floods and storms. Ecosystem services have lately evolved to ecological engineering, in which the ecosystem is imitated or copied to solve a resource problem or recover from disruption, such as reforestation or replacement of wetlands, rehabilitation of mine lands, and restoration of lakes.

Following is a list of the best ideas suggested by students on how to integrate ecosystem services into HERA:

- Add functional water bodies and forests in the game. Trees have a great impact on cities so this feature could be exploited in interesting ways.
- Add a feature that displays the public's satisfaction with their surroundings.
- Add an element of pollution to the city, which players could address through environmental and health interventions. This could be combined with special events such as acid rain, smog, and more.
- Implement different types of terrain coverings, such as concrete, grass, soil, sand, wood, mulch, and more.

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- Implement the concept of carbon footprint.
- Build a government system into the game that allows city inhabitants to debate and speak their mind.
- Add more green infrastructure. For example, the game may include, in addition to a paper factory, a lumber mill.
- Add a sewage system to the city.
- Introduce restrictions to infrastructure development that simulate real-life good practices. For example, given that every energy plant needs a water system for cooling down the game could include a requirement that the player can only build a power plant or a nuclear plant near a lake or a river.
- Challenge players to not only build infrastructure but also collect the building material or mineral resources before building. This activity could be supported by adding mines and forests through which the player can source raw material before developing roads and houses.
- Introduce a scenario that starts with a city that is in a bad condition environmentally, challenging the player must make changes towards a greener solution. Introduce new elements such as wildlife that the player needs to ensure that it thrives.
- Allow players to experiment with agriculture and food production inside the urban area as this could be a key element for a better future.
- Add ecosystem services as background mechanics, supported by a functionality in which they stop working if the player destroys them, for example by polluting, making the game harder. Furthermore, allow the player to repair ecosystem services at a high cost.
- Introduce variations of road services that include trees on the sidewalks, which contribute to the happiness of the city inhabitants but at the same time take space on the sidewalks, which makes pedestrian circulation harder, or take space from the road tarmac, which allows less cars through.

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3.3 Evaluation site in Portugal

For the HERA implementation and validation Virtual Campus worked with Porto Polytechnic, a higher education institution.

Porto Polytechnic (IPP) enrols approximately 20.000 students in its 8 schools and is considered as a space of ideas and results. IPP is a dynamo of cultural change in the city in the region and in the country. IPP is ranked 4th among Portuguese higher education institutions and is the 5th in number of students. In the scope of the project 2 schools were involved:

- The School of Engineering, ISEP, enrols more than 6.000 students in total. As future engineers ISEP's students produce creative solutions for present or upcoming challenges becoming agents of global progress. Each student is unique and ISEP's job is to channel their potential with the spirit of entrepreneurship, teamwork, out-of-box thinking, and technical expertise all of which are key competences for a successful international career.
- With a long history of training in the field of business sciences and enrolling more than 4500 students and over 200 teachers the Institute of Accounting and Administration of Porto has implemented a higher education model of excellence strongly concerned with creating an interface between the academy and its surrounding community. An example of this strategic thinking is the pioneer training in business simulation, a dynamic model of interdependent activities, which is very closely related to the actual context of business life.

The project outcomes were deployed in the following courses:

Multimedia Applications, MSc Degree in Computer Engineering

The course is taught in the 1st semester of the 1st year of studies and enrols approximately 30 students in each academic year. In the last academic year, it run from the end of September until the end of December 2020.

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Course activities are heavily project based. Students work in teams of 4 - 5 must develop a prototype to solve a problem. Along with technical skills, students build soft competencies such as teamwork, communication, creativity, problem-solving, and more.

The interests of students involve information and communication technologies, computer programming, and multimedia. Students are interested in technology, and they would be involved in challenging projects involving the development of innovative ideas.

In course is particularly important due to the scarcity of this profile in the labour market. Students typically receive employment offers before finishing their studies. Some of them are already partly or even full time employed by local companies.

Serious Games, MSc Degree in Computer Engineering

The course is taught in the 1st semester of the 2nd year of the studies and enrols approximately 40 students in each academic year. In the last academic year, the course run from the end of September until the end of December 2020.

Similarly to the Multimedia Applications course, the Serious Games course activities are project-based. Students work in groups of 4 - 5 to design a game, often with a learning context. Along with programming and game design skills, students develop transversal skills related to communication, collaboration, exploration, innovation capacity, and more.

Students have an interest in information and communication technologies, computer programming, multimedia, games. Students become easily employed after graduation while some are employed, partly or fully, during their studies.

Global Businesses, Bachelor's Degree in International Trade

The course is taught in the 2nd semester of the 2nd year of students and enrols 75 individuals in each academic year. In the last academic year, it has run from March to May 2021.

Students were involved in simulations through which they create and manage companies in complex and competitive environments.

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Student interests include business opportunities discovery, business management, accountability, and marketing. They aim to build a sound background for developing their professional career in local companies. At the time that they enrol in the course, students are preparing to initiate their first employment or to continue their studies at the graduate level. The course enables students to focus on identifying and developing international business opportunities. A key point is to identify potential competitive advantages in emerging business opportunities.

3.3.1 Evaluation activities

The organization of the focus groups in Portugal was implemented in collaboration with the School of Engineering and the School of Management of the Porto Polytechnic. This activity took place on March 2nd, 2021 in a mixed model approach: a group of 7 students at the MSc level gathered at the School of Engineering to meet with the project participants while a group of 4 students at the MSc level from the School of Management connected through Zoom®.

Methodology

The activities started with a presentation of the HERA project and learning game by project participants, namely Carlos Vaz de Carvalho, Hannah Schiff, and Carolina Novo, from Virtual Campus. The objectives of the game and available scenarios were presented. Students were then able to test the game but due to time restrictions they were only able to test the most important functionality and existing scenarios. The creation of scenarios was explained but not tried extensively.

Students then had the opportunity to express their views on the game and on the project in a semi-structured way involving the local students and the remote students. The guidelines for the HERA focus groups were followed.

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3.3.2 Student focus group feedback

What students liked

In general, all students thought that the game was based on a very interesting idea, made sense, and showed the potential to develop transversal skills according to what was presented earlier. Some more specific comments:

- The game felt very easy to play and looked very professional even if some students did not like much the low-poly approach.
- Gameplay was fluid in general, but there were some networking issues which at times created problems when playing the game, which requires continuous network connectivity.
- Most of the students liked the simulation-based approach. Management students felt that the management part of the simulation could have been further developed.
- Students would be keen to replay the game. Most of them mention that they would try it again at home.

What students did not like

The interaction with the interface was clear but the use of the mouse was not so easy to manage, particularly for the students that had less experience with videogames.

The interaction with the game objects was slightly more difficult. The logic model for the city was also not entirely clear, in terms of what was necessary to make the city “alive”. There were also too many layers, and their function was not always clear.

More information should be provided about how to use the game but also on the objectives of the scenarios. This relates with the how-to play, the actual objectives of the scenario, but also the learning objectives.

The creation of the scenarios seemed to be a complex process. The different roles, the parameter creation and definition, the fine tuning of the scenario seemed to be a “daunting” task for some scenarios.

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About the activity

The problem-based learning approach was clearly identified. The teamwork, collaboration and leadership skill development possibilities are potentially there but were less explored.

The learning contents were not sufficiently visible. Students did not clearly identify the contents that related to Engineering and Management.

New possible scenarios

Students proposed new scenarios for the game:

- Green mobility scenario to improve mobility and reduce pollution.
- Management of the city as a game scenario.
- Prepare the city for big disasters like flooding.
- Create an "academic" city, that is a city with many students and prepare it for that in terms of mobility, food, etc.

3.4 Evaluation site in Spain

The Universidade de Vigo is a young public academic institution officially founded in 1989. It has 3 campuses, at Ourense, Pontevedra and Vigo, offering degree programs in the fields of science, humanities, technology, and legal-social. Among their centres the HERA evaluation was performed with students of the Telecommunications Engineering School and of the Faculty of Economics and Business Administration.

More specifically, the evaluation took place in the following programs:

Bachelor's Degree in Telecommunications Technologies Engineering

Activities took place in the context of the Projects Lab course, which is attended by 60 students each academic year. The course is taught in the 2nd term of the curriculum from January through April each year. The course applies project-based approaches in engineering. Students work in teams of 4 - 5 to develop a prototype to solve a problem. The

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course further builds soft skills, including teamwork, communication, creativity, problem solving, etc.

The course targets students that are interested in information and communication technologies, computer programming, electronics, signal processing, including transmission, audio, video, etc., and others.

In terms of context, the course aims to address the scarcity of this profile in the labour market. Students receive employment offers before finishing their bachelor's degree studies. Some of them are already part or even full time employed by local companies.

Generally, students like technology and they are eagerly involved in challenging projects.

Bachelor's Degree in Business Administration

Activities took place in the context of the Company Creation and Simulation course, which is part of the 2nd term curriculum and is offered from January until April of each year. HERA evaluation with this group of students took place in the spring 2021 semester. The course is attended by over 60 individuals each year.

This is a simulation-oriented course. Students are involved in simulation to create and manage companies in complex and competitive environments.

The course targets students that are interested in business opportunities discovery, business management, accountability, and marketing.

In terms of context, students that take the course are usually oriented towards developing their professional career in local companies. At this stage, they are preparing to initiate the first employment or continue studying a master. Students are interested mainly on identifying and developing business opportunities. A main point is to identify potential competitive advantages.

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Bachelor's Degree in Economy

Activities took place in the context of the Economy Management course, which is attended by 100 students each year. The course is offered in the 2nd term of the curriculum from January to April each year.

The course involves case studies and seminars. The objective is to describe the business management process from a strategic perspective. Specifically, enables students to identify and analyse the relevant factors when setting strategies both in companies and in other types of institutions so that they reach the competitiveness needed to work in a globalized world and in the face of continuous economic changes. Students master the different strategic alternatives and the tools available to achieve this objective. Projects are based on the knowledge studied in previous courses.

The course targets individuals that are interested in economic strategy and analysis and accountability.

The course addresses 2nd year students who are usually not as concerned with their future as the other kinds of students. It is expected that students are focused mainly on their studies. They need to get a general understanding of basic economic principles related to the management of companies and businesses.

3.4.1 Early review

Students of the Bachelor's Degree in Telecommunications Technologies Engineering and in the bachelor degree in Economics, were engaged in a review with HERA activities in February 2020. They were introduced to HERA goals and proposal and were asked to provide overviews of potential scenarios to be fully developed and integrated into the HERA digital learning game for active learning. Approximately 70 students engaged in this activity. At that time, the students provided ideas for 30 scenarios, and they showed their interest in the project goals. Examples of suggested scenarios include:

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- Leisure plans, namely plans of activities and infrastructures for different citizen groups that allow them to have alternatives of varied leisure and interest.
- Access control, namely limitations of access to beaches and other areas by registration or public transport.
- City routes for cyclists, scooters, and alternative transports.
- Catastrophe evacuation plan.
- Pest response, namely population control of rats, cockroaches, "zombies", or other bugs that may occur in a city.
- Fraud detection regarding tax payment, by evaluating of the standard of living of people to detect bags of fraud in terms of paying taxes to get access to municipal resources.
- And more …

3.4.2 Focus group with teachers

This activity took place at the University of Vigo on January 14th and 15th of 2021. Two focus groups were implemented, one with an economics sciences background and a second one with telecommunication engineering background. Both focus groups, conducted by Manuel Caeiro and Mario Manso, performed similar task, described below.

Participants

Focus group 1: Economics

This group was formed by 3 teachers from the Department of Business Organization and Marketing of the Faculty of Economic and Business Sciences: Fernando Comesaña Benavides, Mercedes Vila Alonso and Carlos Ferro Soto.

Focus group 2: Telecommunication Engineering

This group was formed by three teachers from the Department of Telematics Engineering of the Telecommunication Engineering School: Manuel José Fernández Iglesias, Martín Llamas Nistal, and Fernando A. Mikic Fonte.

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Activity

The HERA game was presented and explained briefly for both the student and teacher roles to the participants using a scenario called “Olympic Village”, created for the activity. Both groups tried the creation of a scenario and played as students in the “Olympic Games” course, which uses the corresponding scenario.

Results

In general, both groups agreed that the game has a lot of potential and fulfils its goal of helping on the development of transversal skills. However, both found the menus confusing at times and suggested some ideas to improve the user interface of the sessions.

Usability and user experience

Game

Both groups agreed that the user interface and controls of the actual game are intuitive. The element that needed more time for them to adapt were the movement controls, as they move quite fast when pressing the buttons, and particularly the zoom function. A slower acceleration would make it easier to handle. They also found too easy to press the “C” (centre view) button by mistake.

Focus Group 1 found the game rather complex, especially for scenario developers, and needed about half an hour to an hour to get comfortable with the game. Focus Group 2 adapted to the game instantly. However, Focus Group 2 suggested improving the infrastructure menu, dividing it or making it clearer, since they could not find the roads at first. More frequent items could be in the first tab.

Focus Group 2 found placing things in the 3D environment tricky sometimes. They suggested to add a top view button (toggle) and the possibility to define the default view.

Sometimes when placing a building on the map it will not show for a few seconds. Focus Group 2 suggest placing a placeholder locally until the info is updated on the server and the actual building shows on the map.

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Menus

Both groups agree that the menus' UXs need an improvement. They found some difficulties to navigate them:

- Back button was difficult to find.
- Student's code input was not clickable, frozen for several seconds.
- Students' course menu was unclear. Participants suggested using clearer pictograms or text, for example mouse-over text as default.
- Students' chat should be visible, when enabled, on one side without hiding the rest of the UX, like in Skype or other apps. It also should show if there are messages when collapsed.
- Letters could be bigger.
- More information on the scenario and role objectives would be useful.

Technology

Both groups agreed that 3D technology in the game is great.

The game was fluid in bursts. Both the menus and the game froze eventually, providing no feedback to user actions for seconds. Focus Group 2 suggested reviewing how connections are made, since this seems to be connection related. Participants provided some hints, such as checking protocol and packet size.

Focus Group 1 suggested using a cursor icon instead of the loupe to avoid confusion with the zoom buttons.

Both groups suggested fixing the freezing issues.

Engagement

Both groups found the game engaging. Focus Group 1 suggested improving user experience issues to increase engagement and Focus Group 2 suggested adding gamification elements like prizes, achievements, rankings, etc.

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Learning and pedagogical aspects

Both groups agreed that the game encourages learning but requires a pedagogical guide of some sort. In addition to the available collection of educational scenarios, the game enables the development and practice of different type of contents. Participants commented that the game could be useful in the following principles, among others:

- Economics.
    - General economics.
    - Industrial organization.
    - Politics, especially for “dirección y gestión pública”.
- Telecommunications engineering.
    - Mobile network planning.
    - Supplementary activity, focusing on teamwork, problem solving, etc.

Both groups agreed that the game improves problem-solving skills and widens learning perspectives allowing a multidisciplinary approach to teaching a subject.

According to both groups, the game has a high replayability, even on the same scenario, as it allows users to try different solutions.

In relation to the game increasing the motivation to continue an academic path, Focus Group 2 disagreed and Focus Group 1 affirmed that this is very scenario-dependent. Using grade-specific scenarios could be useful for this matter. This underscores the value added by the HERA learning game in providing educators with rich functionality for creating broad and diverse scenarios that. The HERA learning supports educators in enriching instructional practices through digital technology that supports experimentation and provide feedback that helps students establish connections between the cause and effect of their actions.

In creating scenarios, some participants faced difficulties in understanding the numbers associated with most of the fields in the role objectives tab. To this end, the group could use the detailed HERA learning game reference guide (HERA reference manual, 2021).

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New possible scenarios

Both groups suggest including a tutorial scenario that demonstrates how to create basic services in a city. More specifically, Focus Group 2 proposed a specific scenario, namely the construction of a holiday city, like Spanish “Marina D’Or”.

3.4.3 Focus groups with students

Two focus groups with were held in Spain in the spring of 2021. One at the Universidade de Vigo and one at the Universidade de Santiago de Compostela. At the University of Vigo mixed groups were involved in a face-to-face event, including students from Economic and Business Sciences and Telecommunication Engineering (see Figure 3). At Santiago de Compostela participants were enrolled in the Computer Science Engineering program, both on-site and on-line (see Figure 4).

Figure 3. Students from different knowledge areas work together at the University of Vigo

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Figure 4. Students from the University of Santiago de Compostela work on HERA

During these activities the project was presented to the students. The project presentation was followed by a small tutorial based on an individual scenario that aimed to expose students to the fundamental functionality of the game. Activities continued with a complex scenario designed for 4 players in which the students worked in teams experimenting with their own solutions. Activities concluded with a discussion that was driven by the questions identified in the focus group template (see section Focus Group in the Appendix).

3.4.4 Learning experiment

The learning experiment involved piloting of the HERA game with students enrolled in the Business Administration program. This experiment took place in hybrid mode. Some of the students were in a regular classroom and participated face-to-face. Most students followed the session online using the videoconferencing facility provided by the university to support teaching. The activities started with a presentation of the project objectives, which was followed by a small tutorial based on an individual scenario that aimed to demonstrate the fundamental functionality of the game. Activities continued with a complex scenario

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designed for 4 players in which the students worked in teams introducing solutions. After the activity, the students filled the HERA evaluation questionnaire.

What students liked

Most students liked the cooperative gameplay, the challenges and complexity that the scenarios provide, and the great number of possibilities that the game presents for addressing a scenario. Some students linked this to the realism in management. The rich environment was one of the elements that students valued the most.

Some students highlighted the ease of learning through the game and the interesting nature of the graphical environment.

What students disliked

One general concern was the graphical power required to play the game fluidly. This implies that the game needs to be executed in powerful computers, while interruptions may be experienced in low end computers. Some students faced usability issues, having problems to place certain objects in the city. A few even reported a bug that occurred when placing multiple items rapidly.

Regarding the graphical environment, some complained that the night cycle was too long and too dark for playing effectively in a well-lit environment.

Some students pointed to the fact that a learning period is necessary for becoming familiar with the game.

How to make it better?

Most students highlighted the need of optimizing the game for low end computers and solving eventual bugs. Some asked for more intuitive controls and menus, an undo button and reducing the in-game night-time.

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New scenario proposals

Students suggested scenarios on industrial revolution, improving an inefficient city, hotel/beach resort management, tourism management, 100% sustainable city, a blank scenario to develop a city from scratch, a real city, and a winter themed scenario with snow.

3.5 Evaluation site in Denmark

The HERA evaluation took place at Aalborg University (AAU), one of 8 universities in Denmark, which enrols 20.000 students distributed over 3 campuses. The 3 campuses are in Aalborg, where is the main university, Copenhagen, and Esbjerg. Around 2.500 students are admitted each year in engineering education. In addition, the university offers economic studies, both as individual studies and as a combination with studies in technology and engineering.

More specifically, the HERA evaluation took place in the AAU Copenhagen campus, which hosts approximately 3.300 students. Approximately half are enrolled in Technology and Engineering, and more precisely in the Bachelor Program on IT Communication and New Media and the Master's Program on Innovative Communication, Entrepreneurship, and Cyber Security. These 3 programs are part of the Technology Faculty at Aalborg University and belong to the Department of Electronics, which is the biggest department of AAU. The students that are admitted in these 3 programs may select among 3 different engineering specialties, and specifically Cyber security, Communication Technologies, and Media and Entrepreneurship. Students enrolled in the 3 programs engaged in HERA project work as part of the problem-based learning program at AAU.

Common characteristics among the students in these programs are:

- They have a strong technical understanding.
- They are solid programmers and often develop applications or services of various forms.
- They understand the process of software development.

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- They understand the market and how that can be included in the service and application development work they are engaged in.
- They understand economic and financial challenges linked to software development and can perform economic analyses of various kinds.

Based on the above student interests lie in communication technologies, programming, software development, market analysis, and how the market can impact on the service development. Students work in cloud computing, machine learning and IoT, and understand how these can be developed from an economic perspective. All students use digital learning platforms, such as Moodle®, Dropbox®, Skype®, Zoom®, and many more.

Generally, there is a huge need for these profiles on the Danish market. Many of the students already have a student job before leaving the university and are in that way well-integrated in a company before they are a candidate. All students engage in problem-based learning and therefore they need soft skills such as teamwork communication, creativity, complex problem solving, how to give feedback, etc. The HERA project evaluation should, therefore, support skills these students need.

The educators that were involved in interviews and teaching include Morten Falch, Anders Henten, Reza Tadayoni, and Jannick Sørensen. They are all instructors in the above educational programs. Three courses have been selected to be eligible for the HERA evaluations:

- Problem-based Learning.
- Innovation and Business Models.
- Managerial Economics and Entrepreneurship.

A total of 50 students across the abovementioned courses participated in the HERA evaluation.

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Problem-based Learning

The Problem-based Learning course is mandatory for all students on their 1st study semester. It targets students enrolled in the ICTE and Cyber Security programs. Learners focus on understanding how to solve complex problems and dealing with the interdisciplinary nature inherent in most educational programs.

Innovation and Business Models

In this course, taught in the 1st semester of the Master in Innovative Communication Technologies and Entrepreneurship, students learn about business development based on communication and media information technologies including network economics, transaction costs analysis, and business ecosystems. Course activities include work in groups where students need to work with business development based on ICT and carry out network economics and other activities. There is a need for technical skills but also skills such as teamwork, communication, problem-solving, and others.

The interests of the students involve ICT, economics, and business development. The students are interested in technology and the matching economy to form ideas for business development.

In terms of learning activity context, students are oriented towards working with a company and understanding what it takes to develop a new business venture. Students are in the early stages of their Master's studies and may apply some of the knowledge developed in other curriculum courses.

Managerial Economics and Entrepreneurship

In this course, taught in the 1st semester of the Master studies in Innovative Communication Technologies and Entrepreneurship, students build experience on preparing a business plan along with a detailed financial analysis of a given project. Students become familiar with ICT tools deployed in financial analysis. Additionally, they build skills on teamwork, analytic sense, communication, and more. Students become familiar with business models, financial analysis, and how to link these to their previous ICT knowledge.

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Students use the knowledge and skills developed in this course in their Master's thesis, which typically, which typically takes place in the following semester and is conducted in collaboration with external companies.

3.5.1 Evaluation activities

The focus group activity took place at the Aalborg University January 28, 2021. The focus group took place on-line. A total of 10 students from the department of Electronic Systems participated. The focus group was conducted by Lene Sørensen from AAU.

The participants were a combination of students enrolled in the 6th semester of the Bachelor Program in IT-COM and the 8th semester of the Master's Program in ICTE. All students were enrolled in engineering programs at Electronic Systems at AAU Copenhagen. Students had a high technical focus in their studies, however with an understanding of economic perspectives. They have experience working in projects and engage in problem-based learning.

The HERA game was presented and explained briefly to students with respect to the idea, roles, and ways of working in the scenario "Smart Parking City", which was created for the activity. They were encouraged to play the scenario and to consider how the game play could be improved.

3.5.2 Student focus group feedback

The students were interested in the game and were happy about the game's rich functionality. Some students were not able to try out the game because they had a Mac® computer. In this case, students watched the tutorial video for the game. Generally, the students thought the game was motivating and had lot of potential. They, however, also had some confusion about the way the different systems of the game were built up.

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What students particularly liked

The students liked the idea of the game-based learning. They agreed that game-based learning would enhance their interests and their motivation for learning. The idea of being able to work on a city and fulfil different purposes was mentioned as a positive element. Also, students compared the game idea with existing games they play. The Sim-city® game was mentioned. The students mentioned that it would probably take them some time to get to know the game due the many options and features of the game but that this would fine if the game is good. The interface of the game was seen to be nice and impressive with respect to the number of features in the game.

What student did not like

As already mentioned, some of the students did not have a Windows® computer which prevented them from trying out the game. It was mentioned that it would be a good idea to make the game so that it could be played in all platforms. The biggest problem mentioned amongst students was that the game's complexity and wide variety of features, which requires some time to build familiarity for playing the game seamlessly. Also, when they are given scenario and haven't developed, it takes a lot of extra time to understand what is already implemented in the city to be able to understand what then can be done to enrich it.

How to make it better?

The students agreed that some improvements could be implemented in the game and that new scenarios could improve the learning experience. The students would like to have more information about the different features of the game, to have information about for example the types of energy subunits or housing just when clicking or hovering over them, that would make the learning much easier. Students would also like to have a small exercise in creating a city themselves before they would work on an existing scenario. They thought that would make it much easier to get understand the idea and the way the city works.

Students suggested that they would like to see scenarios that are linked to real-life. They suggested scenarios to support smarter cities or other ideas where technology is an essential

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part of the scenario solution. A student added that working with problems related to society or companies is highly motivating.

Finally, the students suggested smaller and more videos for new players to familiarize themselves with the parts in the game. That would make it easier for them to start the game and to understand the gameplay.

Another student commented that the idea of the game is great. The student suggested that users need to learn how to work with the game with the support of an easy guide just need to learn how to use new technology. For this purpose, the student pointed out that users typically use services such as YouTube® to look for guides, which make them feel more comfortable when starting to work on something new. The same approach could be used for supporting the HERA game.

3.6 Evaluation questionnaire results

Evaluation questionnaires were administered to students participating in the learning experiments or piloting performed at each of the partner countries. Students were introduced to the game and project goals and were given the opportunity to experience the game by working on a particular scenario towards the achievement of the goals. Different scenarios were tried, mainly the ones based on sustainability, sustainable mobility, and Olympic Games. Nevertheless, in many cases the participants were allowed to explore freely the scenarios available. After the game experience, participants were administered an on-line questionnaire for providing their feedback and evaluation on the game features.

3.6.1 Demographics

The evaluation involved a total of 327 students from 5 countries. Different knowledge areas were represented with the main ones being engineering, business economics, and science, the latter including all related principles. Fewer students were involved in web development and educational sciences.

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This provides a good sample to get different points of view depending on the previous knowledge of students.

3.6.2 Usability

The usability and user experience evaluation results are shown in the next figures. First, Figure 7 shows the results for all students. As it can be observed all considered features achieve a mean value around 5 points in a Likert scale of 7 points. The lower quartile is in most cases at 4 and the upper quartile at 6. Just the features “easy/complicated” and “clear/confusing” get a lower quartile at 3 points. These results show the complexity of the game and of the learning scenarios, involving many different types of buildings, infrastructures and features that need to be managed to perform well in the game.

For the “leading edge/usual” selection where the higher quartile is equals to the median, at 5 points, because 50% of the students answered this value. The evaluation features that provided higher mean values were “interesting/not interesting” and “supportive/obstructive”. The other features are graded with a mark of approximately 5. In summary, these results show the game usability and user experience is quite good; however, the complexity of the game, which is a desirable feature for designing meaningful scenarios, points to the need of additional user support in playing the game, for example through reference guides, learning activity descriptions, or other means.

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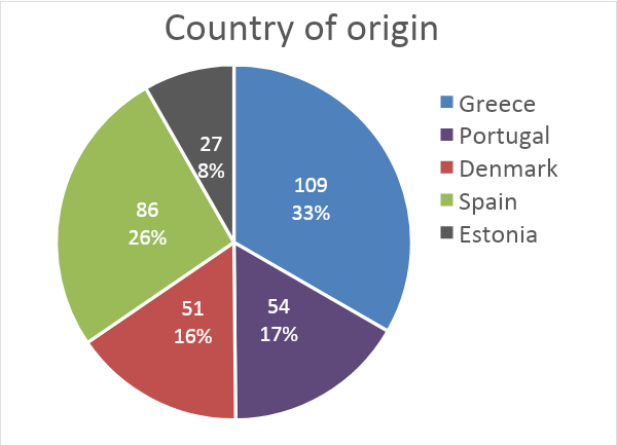

Figure 5. Country of origin of participants

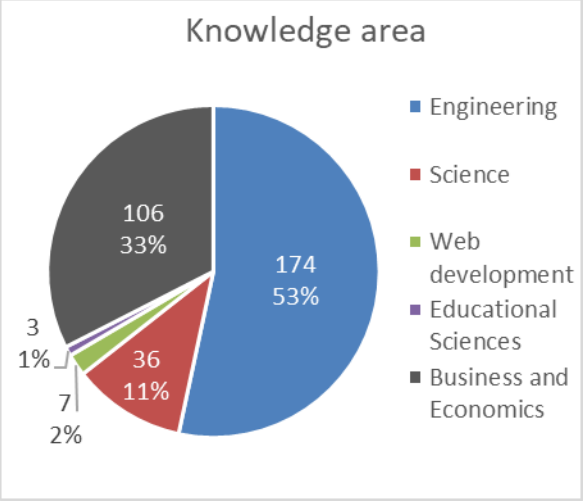

Figure 6. Knowledge area of participants

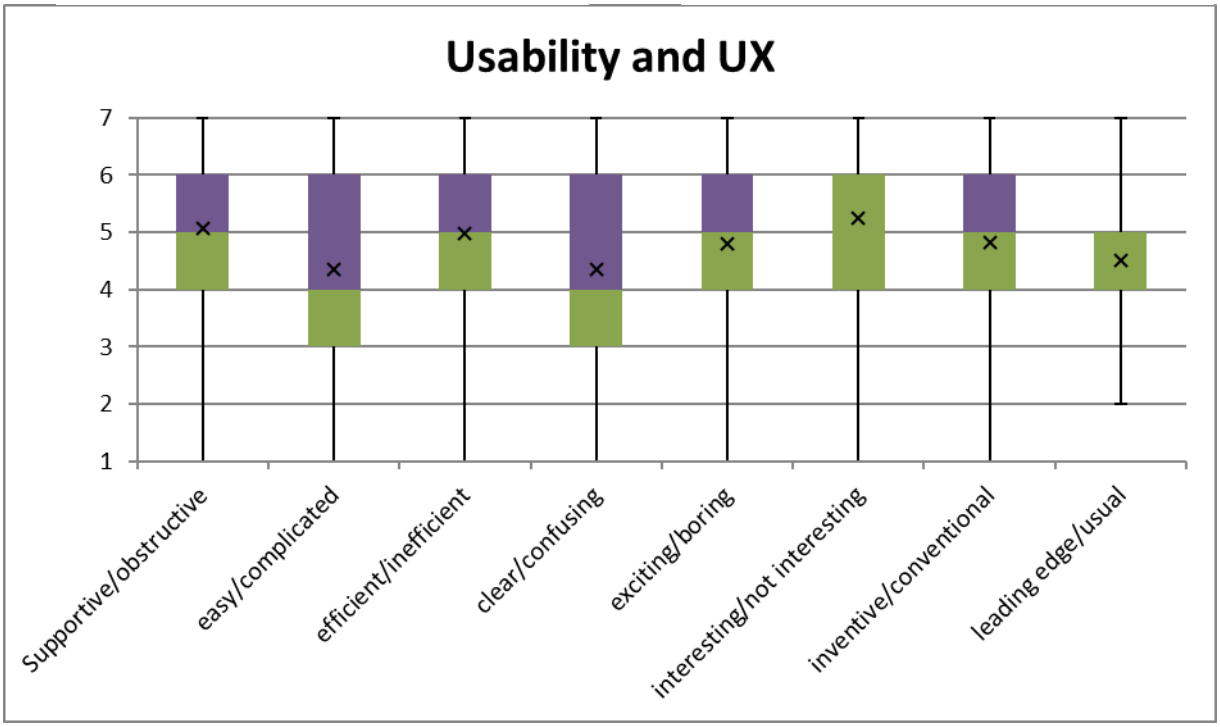

Figure 7. Box plot of the answers to questions about usability and user experience for all students

Next, Figure 8 and Figure 9 show the results disaggregated for engineering students and for economics and sciences students, respectively. As can be observed, differences are minimal.

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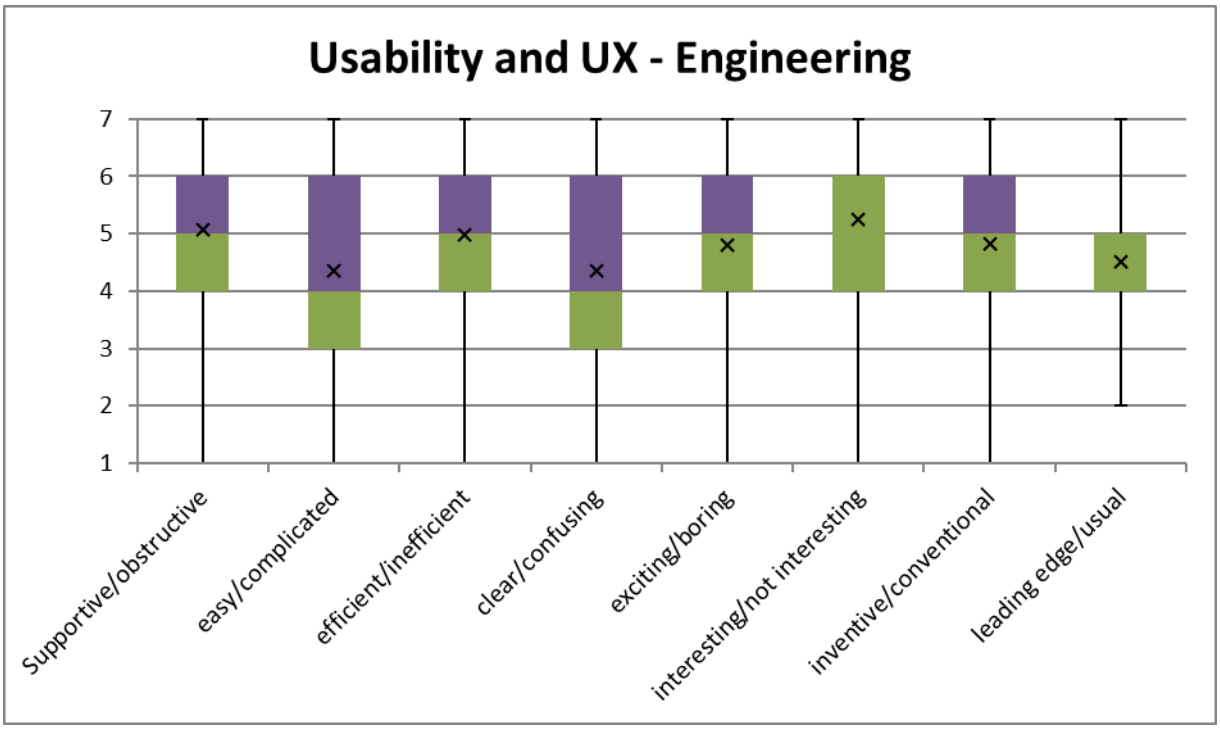

Figure 8. Box plot of the answers to questions about usability and user experience for engineering students

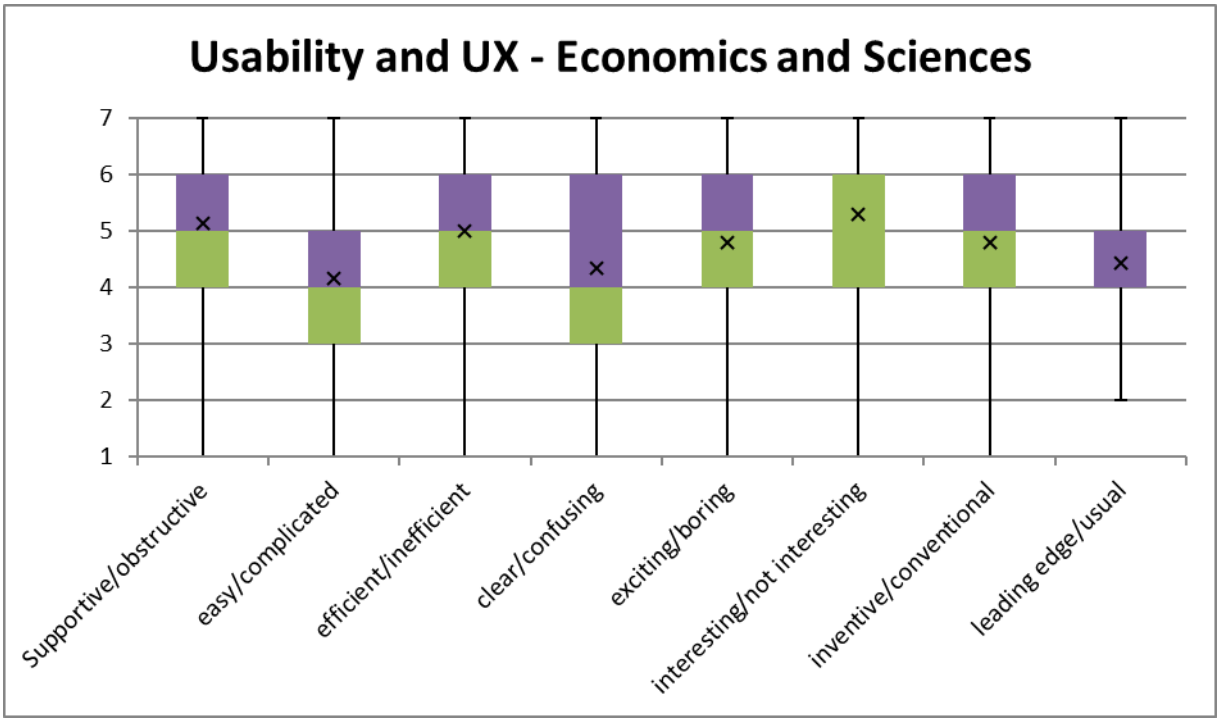

Figure 9. Box plot of the answers to questions about usability and user experience for economics and sciences students

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The economics and sciences students find the experience more interesting than engineering students. This can be due to the learning scenario goals being many times focused on the achievement of features that can be considered as economic issues, related to the good management of scarce resources, and not as proper engineering problems that require the development of technical solutions. This feedback can be used in the design additional scenarios with a more technical focus.

3.6.3 Engagement

Figure 10 shows the results obtained for all students regarding engagement criteria. In this case, the results are a bit lower, with mean values slightly under 5. The worst result comes from the option “I lost track of time”, with a value under 4, which may indicate that students were not deeply involved in the game. In any case, majority of the answers show that students enjoyed playing and felt skilful and concentrated. The gameplay was challenging, and it felt like a rich experience.

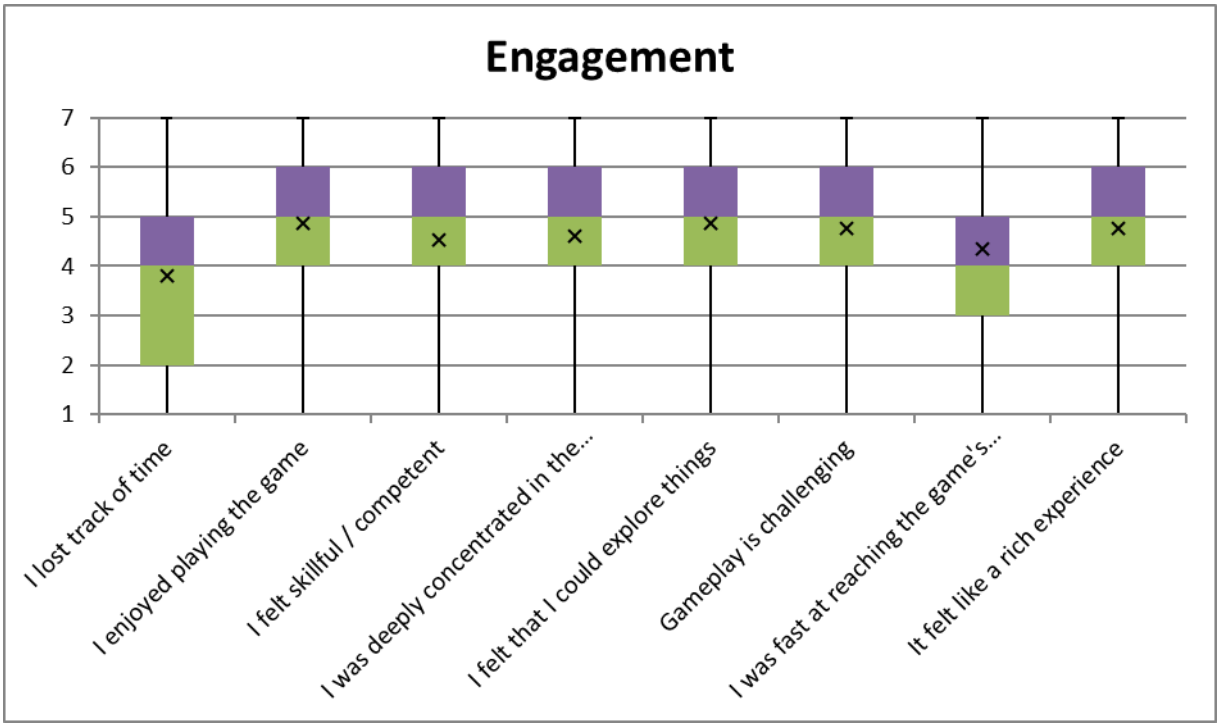

Figure 10. Box plot of the answers to questions about engagement for all students

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Regarding engagement the differences in engagement between the groups of engineering vs. economics & sciences students are subtle. Only the mean values differ slightly. The difference in the mean values is always smaller than 0.02. For instance, for the first option, the value for engineering is 3.795 while the value for business and sciences is 3.778.

3.6.4 Learning and pedagogical aspects

Figure 11 shows the results obtained regarding learning and pedagogical aspects. As can be observed, all options have a mean value around 5, with the lower quartile above 4 in all cases. The option that is most selected by students is “Teamwork is key to get good results”. This is a key aspect of the HERA project, which is heavily collaborative. Teamwork can promote the development as valuable soft-skills such as communication, collaboration, coordination, group-management, and more. This good result is confirmed by the last option “The game allowed me to work with my teammates”, that was also highly favoured.

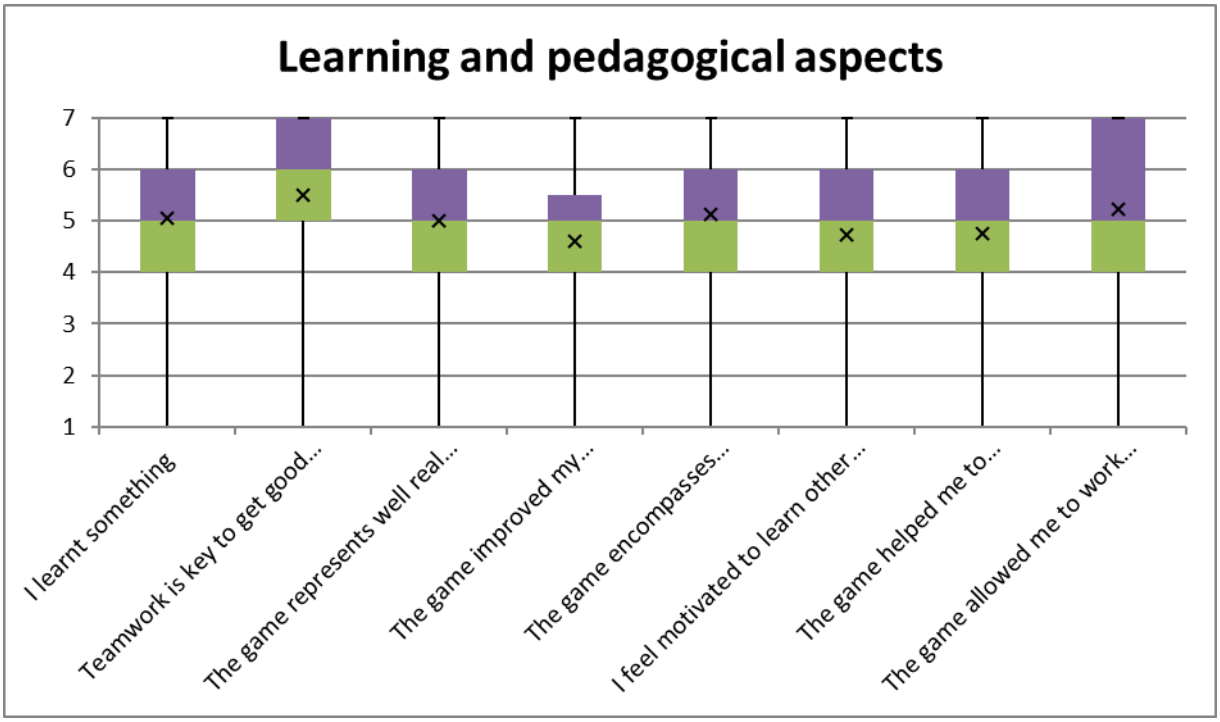

Figure 11 Box plot of the answers to questions about learning and pedagogical aspects for all students

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No significant differences can be observed between the two groups in relation to learning and pedagogical aspects.

3.7 Discussion

3.7.1 Ease of use

According to user interviews, the game becomes easy to use after the first play session. This has been confirmed through the documented feedback on learning experiences. During the first exposure to the game, the users need some time to familiarize with the interface and gameplay having to learn where the tools are in the game menus and how to develop the most complicated systems in the game, such as the electrical power. After that, most users could focus on the game experience finding it easy to place buildings, check the layers, and follow the objectives of the scenarios. Moving the camera around the map can be challenging at first for those players not used to play games. These findings are confirmed by the questionnaire results regarding usability and UX.

Regarding scenario editor, most found the use of the scenario and course creation tools easy. Designing an activity on a scenario was more challenging, since there are lots of variables to balance to get a well-designed experience, from map design to goal values and role capabilities. Thus, the main difficulties are related to the design of learning activity itself and not the tools used for it, something tackled in the project with the proposed learning sheets, scenarios, and good practice guidelines.

3.7.2 Acceptance

Most players found the teamwork very attractive, and many teams asked to continue developing their scenario after the pilot session.

Most teachers highlighted the potential of the game to foster teamwork, communication skills, and other transversal competences. However, they also highlighted the difficulty to create well-balanced activities at first.

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3.7.3 Relevance

According to the results shown in 3.6.3, most players enjoyed playing the game, found it a rich and challenging experience in which they felt competent and could explore different approaches. Around half of the users needed some time to achieve scenario goals. Less than half lost track of time while playing. This means that the game is enjoyable and challenging and it is not a deeply immersive experience for most users.

A high number of players asked to continue playing their scenario after the pilot sessions. They also asked if they could team with their friends to explore again the same scenario from a different angle or even different scenarios. This shows a high level of engagement, especially in teams that worked well together. In fact, how well a team worked together affected the level of engagement of the students.

3.7.4 Effectiveness

The game offers the possibility scenarios that range from simple and easy to solve to complex, multiplayer and role dependent. This makes the suitable for a wide range of experiences and activities. Replayability is one of the most valued aspects of the game since there are many approaches to solve any scenario allowing a team to explore different approaches in each run, which can trigger different learning opportunities from the same activity.

Something really valued by students is the possibility that the game offers to learn concepts with a practical approach instead of through the usual lectures.

3.7.5 Ease of integration

According to the results from the pilot experiences most teachers would include it in their programs to foster transversal skills, especially teamwork, problem-solving, resource management and communication skills. This is particularly the case when using a well-designed scenario that includes roles with different capabilities and dependencies between

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them, forcing team members to work together. Most educators also agree that the design of the activity would be key to get a good result in terms of transferability of skills.

3.8 Integration of participant feedback into the game

The input by evaluation participants was integrated into the HERA learning game in an on-going manner. This ensured the formative element of the evaluation, namely using evaluation findings to enrich the project outputs. Following is a list of enrichments implemented into during the on-going HERA evaluation.

- **Understanding scenario objectives**. The scenario editor includes an element for describing objectives, which scenario creators may use to provide detailed information to users.
- **Understanding scenario goals**. Similarly, the scenario editor includes an element for describing the objectives of each role for the benefit of players.
- **Freezing of the screen**. The game is designed to be played with continuous network connectivity. Connectivity is necessary for supporting the games collaborative nature, which allows teams of possibly remotely located students to collaborate on a common goal. The needs to be played in a location with good connectivity to ensure that all functionality is always available. This is a common strategy for game development in recent years.
- **Software "bugs"**. Small technical problems that naturally arise in software development were fixed in a continuous manner using input from evaluation of the alpha and beta versions of the game.
- **Use of layers**. Layers provide an additional element for structuring rich and rewarding scenarios. They allow scenario creators to define properties for parts of the city, such as pollution or crime levels. Layers are not required for designing a basic scenario. However, they do provide optional added value to advanced scenario developers.

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- **Moving around the screen**. The game uses typical movement keys of popular 3D games. Individuals that have been exposed to games face no difficulty in moving around the screen. For individuals that have not been significantly exposed to games, it is recommended to allow some training sessions for becoming familiar with typical game functionality.
- **Allowing more visibility in the game night cycle**. The light was modified to ensure higher playability.
- **Providing an undo button.** A bulldozer feature allows players to remove structures and make corrections.
- **Assets for creating a scenario**. The game provides a very rich collection of assets for creating a scenario. These include small, medium, and large houses, small and large condominiums, different types of skyscrapers, different types of roads, different types of energy production plants, industry, farms, cultural centres, health centres, universities, schools, police stations, fire stations, phone providers, internet providers, different types of parks, and a lot more. The combination of these offers a wealth of opportunities for designing diverse scenarios that address broad objectives and constitutes one of the strengths of the game. For a detailed list of available assets, please refer to the HERA game reference manual (HERA reference manual, 2020).
- **Menus**. The game offers rich functionality for creating a scenario. For this reason, it is necessary to organize the available features in menu tabs for their easier discovery. Menus were modified to group functionality in broad categories, such as infrastructure, public services, culture, industry, businesses, residences, and more.
- **Providing information on game structures**. The magnifying lens feature of the game allows players to get information on each structure available in the game by placing the lens on top of each structure.
- **Suggestions for additional scenarios**. The HERA proposal foresees 3 educational scenarios. Currently 12 scenarios are available. The HERA game has gone a step

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further. It does not provide students and educators only with hard coded scenarios. Rather, it further provides a scenario editor which, in combination with the rich collection of assets, allows educators and students to create new scenarios at will to address emerging educational needs. As a result, any number of scenarios can be created through the HERA learning game.

In addition to the above, a collection of supporting material has been developed for facilitating the smooth creation of new scenarios and gameplay. This includes:

- The detailed HERA **game reference manual**.
- **Learning sheets** that demonstrate how an educator or student can create a basic city. This helps overcome any initial adaptation period that is necessary for becoming familiar with the HERA learning game (HERA instructor support content, 2021).
- **Learning sheets** that explain the goals and roles of available HERA learning scenarios, which can further support user understanding and act as inspiration for the creation of additional learning activities (HERA instructor support content, 2021).
- **A detailed video on HERA game functionality**, which provides step-by-step visual instructions on how to use all features of the game. The video is extensive (HERA instructor support content, 2021).
- **Videos on select scenarios**, which describe scenario objectives and roles and further support the understanding of the HERA learning activities (HERA instructor support content, 2021).

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4 Good practice guidelines

Based on the feedback generated through evaluation activities this output concludes with the development of good practice guidelines recommending how to best deploy the HERA methodologies and tools for maximum benefit.

The main purpose of the guidelines is to provide recommendations to best deploy the HERA methodologies and tools for maximum benefit of teachers interested in the project results.

As stated in the project proposal “The purpose will be to provide external stakeholders with information that will help them exploit the HERA experiences for enriching their own educational offerings for the benefit of their students”.

The good practice guidelines have been classified in accordance with the stages involved in the use of HERA results: preparation, learning delivery, and conclusion.

4.1 Preparation

This section considers best practices for the activities performed before the delivery of the activities to the students. It considers issues regarding the preparation of the scenarios.

TITLE
Carefully select scenarios that add value to existing educational practices
ISSUE
Ensuring that the proposed game-based learning intervention is seamlessly integrated with existing curricula and educational activities. Ensuring that selected game-based learning scenarios add value to existing learning practices enriching the experiences of students and helping better address educational goals. Supporting educators in the selection as well as detailed design of educational scenarios through the HERA learning game in a manner that promotes blended learning that integrates

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classroom instruction, practical activities that take place in a digital environment, collaboration, and more promoting the development of problem-solving skills.
SOLUTION
Scenario selection is a key activity in problem-based learning. To ensure that scenarios are relevant and meaningful, educators may initiate the learning process by engaging students in a scenario suggestion activity. This activity may offer several advantages to students: • It promotes creativity and innovative thinking, as students are asked to conceive new ideas (Kilroy, 2004). • It promotes learning autonomy and engagement in the learning process by allowing students to influence the direction and focus of their learning. • It generates a rich pool of ideas that the educator may use for selecting scenarios that best address student needs and interests. • It allows students to feel that they own the learning process as they help co-design educational content with their teachers. Once a pool of scenarios is created the educator may select a specific small number that will be developed into full educational activities in the HERA learning game. Criteria for selecting specific scenarios may include: • The frequency by which they appear in student responses. • Their link to educational objectives of a formal course. • Their complexity and depth that allows the definition of interesting roles for students to undertake. • The interactivity that they can provide between learners and the HERA game. • The degree of collaboration they require for their implementation, which encourages students to develop teamwork skills in a manner that simulates real-life. • The degree of interdisciplinarity that the scenario requires to be implemented, integrating knowledge from diverse thematic areas and sectors, promoting

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collaboration in multidisciplinary teams in a manner that simulates real-world practices.

- The different competences, in particular soft skills such as analytical and critical thinking, which the scenario helps develop through virtual collaboration (Duch et. al, 2001).
- Their relevance to current industry and societal needs.

On the other hand, an educator may select a scenario by reviewing the pool of available scenarios that are published through the HERA learning game and can provide inspiration.

Finally, an educator may select a scenario through independent research on the internet on related problem-based learning activities that can be adapted for integration in the interactive digital environment of the HERA learning game

AUTHORS	Hariklia Tsalapatas, Olivier Heidmann (UTH)

TITLE
Ensure that scenarios have balanced roles for interesting team play
ISSUE
The hardest activity for creating scenarios is to balance player roles and game options. In addition, a scenario needs to support curricula learning goals.
SOLUTION
While designing the scenario, an educator needs to think through the student roles and capabilities of each. Roles need to be in balance to let the player be fully engaged. While creating new scenarios test the given values by playing the game and assuming the foreseen roles. Well-designed scenarios and roles align a game with learning objectives (Hotte et. al, 2017).

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An educator should try to avoid situations where some roles are assigned few tasks while other roles are assigned a heavy workload because other players are strongly dependent on their activities. Ideally, every role should have at least some freedom and possibility to reach at least some of the goals independently of others.

Role and scenario goals must support learning goals of the curricula and the theoretical background of a given course.

Before creating the new scenario try some predefined scenarios already included in the HERA game. It may be easier to use some of those as base for creating a new scenario as they allow scenario creators to not start from scratch by building a new city, setting up the landscape, and more. The scenarios even include some pre-created cities that the creator can modify and adapt for addressing new learning needs.

To make scenarios more relevant for students a teacher may try to include some localization, namely some architectural elements from your city or other aspect of society. The teacher may also engage students to scenario creation, for example through a brainstorming session that aims to map relevant real-life problems they want to work with or through a discussion on potential roles and their capacities.

AUTHORS	Prof. Jaanus Terasmaa, Triinu Jesmin (TLU)

TITLE
Use available scenario templates that provide functional cities to create your scenario
ISSUE
To create a new scenario can be complex and time consuming
SOLUTION
Creating a scenario from scratch can be time consuming. HERA offers several base scenarios which include a fully functional city map ready to be customized. Scenario creators can try

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them, get a private copy, and add or remove elements or introduce conflict depending on the learning goals and the style of game design adopted. Unless a very specific scenario with certain rare features is needed most scenarios can be created starting with a base scenario. Then, the scenario creator simply needs to define the roles and goals to get a complete playable scenario.	
AUTHORS	Manuel Caeiro Rodríguez, Mario Manso Vázquez (UVigo)

TITLE
Choose a problem that can be seen or experienced in real-life and is relevant to students
ISSUE
Students are more motivated when working with complex problems that are related to something they can recognize in real-life or something or is relevant to a company or municipality (Harun et al., 2012). It is also with real-life situations, that the complex dependencies between different aspects of the problem, such as economic, engineering, or other types of interests become clear and relevant. The HERA city game includes a pre-defined set of real-world relevant scenarios. These can all be used for problem solving but may also offer inspiration to educators who can adapt one of the scenarios to the specific area of interest of the curriculum and perhaps a local or national societal element that makes the problem, the scenario, and therefore the learning game more interesting, motivating, and educational for students.
SOLUTION
The educator can do several things to design an interesting scenario. She may establish contacts with companies, municipalities, or others to identify a problem or to even involve these as external stakeholders in the definition of the problem. Another possibility may also be to introduce students to a problem that is in the news.

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The HERA city game already introduces a collection of scenarios that are defined from current, complex, and relevant problems (HERA learning game, 2020). They include:

- Smart parking, which addresses the problem of too much traffic in cities through smart marking solutions.
- Designing a smart, sustainable city, which addresses the fact that many cities have a vision to become more sustainable but at the same time to use more technology to make smart solutions to central elements in society such as for example managing traffic or building more energy relevant houses
- City preparedness for COVID-19, which focuses on building infrastructure for preparing the city to address the COVID-19 pandemic.
- And more.

If the teacher needs to define new problems for addressing specific educational needs, it is possible to define new scenarios or modify existing scenarios to adapt them to a new problem.

AUTHORS	Lene Sørensen (AAU)

TITLE
Make sure that computer equipment has enough power to execute the HERA scenarios
ISSUE
The HERA city game is developed for Windows® computers. However, in some countries, students in higher education institutions, such as Aalborg University, students may also use the Mac® operating system. Furthermore, many students may only bring a tablet or even just a mobile phone to go on-line. The diverse operating systems may be a challenge in a class where students need to collaborate on joint projects.
SOLUTION

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The educator should present the requirements for the exercise on a HERA scenario in due time for the students. This will allow students to prepare and to bring a Windows® device to class if they own one. If possible, the teacher can borrow extra Windows® computers, for example laptops, to accommodate the entirely of the class. Another idea is to execute learning activities in a lab with Windows® computers, which most universities have. This may eliminate the risk of some students not being able to participate in the exercise at equal levels as others. Finally, of course, the teacher may divide the class into teams that all work on the same scenario. In that way, the students can work on the number of computers which are available in the room and benefit from collaboration not only with their team members but also with other teams.	
AUTHORS	Lene Sørensen (AAU)

4.2 Learning delivery

TITLE
On-boarding
ISSUE
Students may not be interested to start learning a new game and its functionalities. It may seem like too big trouble for just one assignment in school. Students do not want to invest time and effort into something they might not see the value of at first. So, preparation activities need to demonstrate to students that there is value in their effort.
SOLUTION
To engage students and make them invest their time and effort the educator needs to highlight the benefits of learning activities. One of the solutions is exemplifying in the beginning of an activity why this is important and what are the elements they are going to

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learn. Delivering an introduction to the activity learning topic and the game mechanics helps build a bridge between real-life and the game world. When students understand the goals and expectations of a learning activity they are more willing to invest their energy. Another solution is to immerse students in the learning activity and ensure that they enter a state of "flow". Flow is a state that an individual enters when she is so immersed in an activity that she loses track of time and the environment (Sillaots, Jesmin, 2016). Games are known to introduce flow with quite ease if the balance between challenge and skill level is optimal and tailored to the competencies of the player. Making sure that students understand what is expected from them and what are the goals makes reduces frustration and as a result leads to balance and flow engaging students with the game content.

AUTHORS	Triinu Jesmin, prof. Jaanus Terasmaa (TLU)

TITLE
Encourage students to perform individual research before collaborating with their group members towards solving a scenario
ISSUE
HERA is a problem-based learning intervention (Delisle, 1997). To maximize the positive impact from its deployment the educator must embed HERA in well-accepted problem-based learning design. Through this approach, the HERA learning game will become a valuable digital tool that complements existing problem-based learning practices that promote exploration, experimentation, collaboration, and synthesis of new knowledge through the integration of knowledge from diverse fields. It will also become a valuable tool for promoting the development higher-order learning skills through analytical thinking, creativity, evaluation of diverse ideas, integration of knowledge from diverse fields, and validation of outcomes.

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SOLUTION	
Many implementations of problem-based learning exist. However, common patterns appear in most of them. Problem-based learning is triggered by a problem that needs a solution. The problem challenges students to re-evaluate their perceptions of the world, engaging in the research of resources for developing a better understanding of the problem and its parameters (Barrows & Tamblin, 1980). Subsequently, students typically brainstorm in groups towards synthesizing a solution, introduce designs, develop prototypes, and evaluate their outcomes (Kilroy, 2004). This applies to the HERA learning intervention as well. HERA is heavily collaborative, exposing students to the way multidisciplinary teams work in real-life. However, independent research is also significant. Students can be encouraged to work autonomously before engaging in team collaboration to have an opportunity to develop their ideas, to build understanding of related work, and to become able to integrate this new knowledge with peer input for a collective optimal result that will emerge through group work.	
AUTHORS	Hariklia Tsalapatas, Olivier Heidmann (UTH)

TITLE
Use a scenario that may be individually played to introduce students to the game
ISSUE
Players may face difficulties interacting with the elements of a scenario and to understand the gameplay. This is particularly the case when the scenario is collaborative involving different participants. This is quite common because many students do not have any experience playing a city-based game. In addition, the HERA city game includes some specific features that are not available in other similar city games.
SOLUTION

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The educator may ask students to solve a simple individual scenario. Students can experiment and play in such a scenario to understand the different game elements and options available. For example, to understand the goals to be achieved and the capabilities available to the player for doing so, to become familiar with the interface, or to understand the state and needs of the different elements. Also, to place the elements on the scenario canvas and to see their behaviour and evolution towards the achievement of the scenario goals.

Some students may struggle at this stage. For this reason, it is important to give them some time to explore and become familiar with the game mechanics. In addition, it may be beneficial to encourage students to explain to each other the game world, rules, and mechanics.

In cases where students do not have any experience playing similar games the teacher can demonstrate to students as an introductory activity how to play the individual scenario using a projector. The teacher may demonstrate a potential solution step-by-step showing the different elements involved, where information about them can be observed, what the meaning of menu items and graphical conventions in the game indicate (for example, red implies that there is some problem in the city design; green implies that everything is fine), how to use the HERAPedia (HERA learning game, 2020) exhaustive catalogue of elements, how to situate the elements on the game canvas, how to observe the achievement of the goals, etc.

Some scenarios already available in the HERA public repository can be used for this purpose, such as the Tutorial one.

AUTHORS	Manuel Caeiro Rodríguez, Mario Manso Vázquez (UVigo)

TITLE
Evaluate learner newly developed knowledge through debriefing

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ISSUE
Assessing newly developed knowledge is key for ensuring the effectiveness of emerging learning design, such as problem-based methodologies. In the context of HERA, problem-based learning takes place through gamification. Serious games offer significant advantages in learning: they motivate learner engagement, they help learners understand the consequences of their actions by establishing cause and effect links, they are highly interactive providing real-time feedback, they have clear goals that can be connected to educational objectives, generate among students a sense of affiliation and achievement, and more. One of the main criticisms towards learning games is that in some cases students may make random choices, which do not lead to knowledge increase. A methodology needs to be established to ensure that students make conscious decisions based on new knowledge and fruitful collaboration.
SOLUTION
Learning games are best deployed in learning cycles in which the educator presents new concepts, allows students time to engage with the game, and follows-up gameplay with a debriefing session in which students are encouraged to present their solution in a manner that demonstrates their level of understanding. In this context, evaluation through debriefing is an educational tool. It can have powerful benefits not only because allows the educator to build a good understanding of knowledge increase among students, but also because it challenges students to defend their choices through effective presentation skills. Learning games are effective educational tools. The question is not whether they should be deployed in learning, but rather how (Garris et. al, 2002). Learning games are not designed for replacing traditional instruction. Rather, they are complementary digital educational tools that can enrich instructional processes and learning experiences for students. The integration of learning games in broader, blended learning activities that integrate traditional instruction, exploration and experimentation, collaboration, and more activities can help reach educational goals in a safe and cost-effective way, for example when physical

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resources, such as labs, are not available.	
AUTHORS	Hariklia Tsalapatas, Olivier Heidmann (UTH)

TITLE
As an educator, act as a facilitator and a guide in problem-based learning
ISSUE
Problem-based learning is a student-centred approach. In traditional instruction, the classroom setup demonstrates the role of the educator as a conveyor of information. Students and the educator are positioned opposite to each other, highlighting the leading position of the educator in the process. On the other hand, in problem-based learning the role of the educator changes. The educator becomes a facilitator of learning (Duch et. al, 2001). Educators walk around the classroom answering questions, guiding, and helping students that work in groups reach their goals. Educators may be reluctant to relinquish the control of the classroom by allowing students to drive the learning process based on their interests and needs. However, what is important for educators to understand is in problem-based learning their role is not diminished but rather evolves. The educator supports, encourages, coordinates, extends student understanding of the subject matter, and helps build student self-confidence in their problem-solving capacity.
SOLUTION
To encourage the student-centred nature of problem-based learning, educators may change the configuration of the classroom so that it better supports collaborative activities. In a laboratory, computers may be placed on islands around which groups of students work. Similar setups may be pursued in traditional classrooms. Changing the setup of the classroom positively affects the interaction dynamics of the class, encouraging students to become independent learners that valuably contribute to teamwork in their groups.

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If learning takes place virtually, collaboration can still be facilitated among team-members. In the context of HERA, educators may encourage students to deploy the brainstorming tools of the application for sharing ideas that their peers can see and edit in real-time building on each other's contributions towards reaching a solution. They can further encourage students to use the in-app collaboration facilities that allow them to discuss topics in an embedded chat. These digital group-working features allow students to collaborate whether they are in the same room or not, enabling the implementation of the problem-based learning process beyond the classroom.	
AUTHORS	Hariklia Tsalapatas, Olivier Heidmann (UTH)

TITLE
Don't explain everything on a scenario in one iteration; rather use several iterations to build knowledge and skills
ISSUE
A too-guided game experience reduces skill development gains and feels scripted. It is preferable to allow students room to explore.
SOLUTION
The educator may present the scenario, the roles, and the goals involved and let the teams play and explore. This method encourages students to analyse the game map and figure out how to introduce a solution to the scenario without any external input. Most of the time students will manage to solve any issues they encounter within their team. If not, after a certain amount of time, the educator may give further instructions for those teams who have not advanced enough in the resolution of the scenario. It is very interesting to let groups that have succeeded in the completion of the game to explain to the whole classroom their strategy. The educator may repeat this process until teams have introduced solutions to the scenario, exploiting the power of games as complementary tools for achieving educational

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objectives (Michael & Chen, 2006)	
AUTHORS	Manuel Caeiro Rodríguez, Mario Manso Vázquez (UVigo)

TITLE
Be an effective facilitator while students work on a problem
ISSUE
Students can be very insecure about how to deal with the problem, how to engage in the game, and even on how to collaborate to find a solution (Harun et al, 2012). Students may be less motivated if they encounter problems in collaboration, failing to come up with innovative ideas on how to solve the problem or how to engage in the game. If students are less motivated, they will not achieve the learning which is the end-point of any problem-solving activity, including HERA city game.
SOLUTION
The teacher must act as a facilitator. He needs to be continuously available to answer student questions and oversee student teamwork. Also, it may be a good idea to introduce smaller goals for the students to fulfil, allowing them to reach a solution step-by-step. Introducing a stepwise focus on smaller problems and solutions can foster motivation and support learning throughout the whole process. It can further allow the teacher to understand when some aspect of the game or scenario is not well understood. Using a HERA scenario for in stepwise learning is easy. The teacher can define how often he wants to receive some form of report from the teams working with a scenario, as well as define deliverables to be handed in at important milestones. Examples of deliverables can be for the team to provide a written overview of the problem, namely, to provide a problem definition from their own point of view, for students that assume individual roles to describe their strategy towards achieving their goals, and more.

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On the other hand, educator feedback can be a key motivational factor for students working on complex problem. The teacher as a facilitator must provide continued feedback to ensure that student activities are aligned with learning objectives and that students stay motivated through encouragement and positive comments.	
AUTHORS	Lene Sørensen (AAU)

TITLE
Allow sufficient time for students to work with the scenarios
ISSUE
It can be overwhelming to understand both the complex problem, as well as a particular scenario. If students are not familiar with the HERA city game and its scenarios, they will need some time to understand the game, its features, and the way it works. The time required for students to familiarize themselves with the game may be an hour or more. This may slow down the actual work towards problem-solving skill development, which is the objective of HERA.
SOLUTION
The educator needs to ensure that she allocates appropriate time during which students may explore the game and scenario operation and collaborate with team members without working on a particular problem. One solution for achieving student familiarization with the game mechanics could be for the students to build a small city from the beginning to understand the process step-by-step. Subsequently, perhaps in another class, the educator may present a specific problem in the form of a learning scenario. At this stage, being already familiar with the game mechanics, students will be more capable of focusing on addressing the problem objectives. This approach will foster more effective learning and teamwork.

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AUTHORS	Lene Sørensen (AAU)

TITLE
Allow students to reflect
ISSUE
Maximize the learning effect and consolidate the knowledge generated by game scenarios by introducing repetition in learning (Bjork., et al, 2013)
SOLUTION
To ensure that the learning from the game scenario is deep and efficient the teacher may introduce a recap of core concepts. A review of concepts may take place before the engagement of students in the HERA game. What is most important, is that a recap takes place after the completion of the activities for ensuring that the student choices are conscious (van Staalduinen, J.P. & de Freitas, 2011). This may be achieved in several different ways: • A more traditional teacher-centred way of a short recap lecture using slides that highlight the main concepts. • A short test for assessing the learning of students, for example a quick Kahoot® test. • A more student-centred way that is discussion-based and may be implemented in pairs or small groups. • A general discussion on how students achieved their goals may also be beneficial for further building knowledge on scenario concepts through exchange of views with peers. • A competition among students or groups, for example on naming the most concepts introduced by a learning scenario. • A creative approach, such as encouraging students to suggest test questions based

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on the knowledge they developed.	
AUTHORS	Triinu Jesmin, Prof. Jaanus Terasmaa (TLU)

TITLE
Introduce homework
ISSUE
To make the learning more efficient and transferable to real life, the content should be presented in many different forms (Soderstrom, Bjork, 2015)
SOLUTION
One way of adding homework to playing the game scenarios introduced in the classroom is deploying the flipped classroom methodology. In flipped classroom (Brame, 2013), students are given relevant material such as text, videos, and more prior to playing the game so they familiarise themselves with and build knowledge on core concepts and key topics. This method is time-efficient and makes collaboration and discussion among students more intense as they are already familiar with the topic and goals. A second possible solution is to assign students homework after playing the game in the classroom. The focus of the homework may be, for example, writing an essay about their learning experience and processes, asking themselves what they have learned and how. This is beneficial in two ways. First, it allows students to feel important as their personal experience is perceived as relevant. Secondly, the repetition and reflection on the learning elements promotes further understanding, allows students to apply the new knowledge in real-life contexts, and ensures that learning is more efficient and deeper.

AUTHORS	Triinu Jesmin, Prof. Jaanus Terasmaa (TLU)

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4.3 Conclusion

TITLE	
Use the HERA game to motivate students to develop their programming and coding skills	
ISSUE	
Engineering students normally are taught the basics of programming but then only a few engineering programmes fully develop this ability. Nevertheless, many engineering students would like to further build their programming skills to broaden their career options as all engineering professions nowadays depend heavily on informatics.	
SOLUTION	
The educator may demonstrate to students how a scenario is created providing them with access to the base code of the game. Students can then relate the functionality of the game with the game software code. They could then be asked to think of a new city factor or parameter that could be programmed and added to the game. Then they could create a new scenario that makes use of that aspect. Games can be a great tool for promoting the development of programming skills in all ages (Tsalapatas, 2013).	
AUTHORS	Carlos Vaz de Carvalho (Virtual Campus)

TITLE
Use the HERA game to discuss social and cultural aspects of engineering and economics
ISSUE
Engineering programs are essentially technical and do not provide students with the necessary reflection on the role of engineering and economics in society. The fact that engineers have completely changed the world through achievements such as modern homes, bridges, space travel, cars, and the latest mobile technology this is seen from the

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technological point of view and not necessarily from a societal point of view (Avny, 2011).
SOLUTION
Teachers can use a game scenario that shows the evolution of a city to discuss cultural aspects, such as the migration from villages to large cities, and the current opposite movement, the impact of technological development on quality of life, and more. Students may discuss which areas of modern life are more affected by engineering and economics and deflect on the ones that are not frequently associated with that, such as health, nutrition, and others.

AUTHORS	Carlos Vaz de Carvalho (Virtual Campus)

TITLE
Integrate learning objectives in the game scenarios
ISSUE
Educational games have learning goals and objectives like any other educational tool. However, the relation between gameplay and learning objectives is not always clear for teachers or for students. This results in the limited deployment of games as learning tools (Garris et. al, 2002).
SOLUTION
The educator may design a scenario emphasizing particularly the learning objectives. The objectives should be very detailed, concrete, and even quantifiable. The educator may discuss with students how it would be possible to evaluate if the learning objectives have been reached by students while they play the game. The educator may ask the students to play the scenario and verify that they reached the learning objectives. Subsequently, the educator may encourage students to discuss with their peers the achieved results and the possibility of games being effective learning tools.

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AUTHORS	Carlos Vaz de Carvalho (Virtual Campus)

TITLE
Use HERA as a user experience testing platform
ISSUE
The concept of user experience is relatively new and sometimes not well understood by teachers and students. A game like HERA is a great tool to test user experience as it provides interaction, immersion, an extended, potential different uses, and more.
SOLUTION
The teacher may introduce the concept of user experience to the students, explain the different aspects involved, and show how user experience can be evaluated (Kujala et. al, 2011). For this activity, the teacher may select a single scenario that will be tackled by all student teams in the class. The teacher may encourage students to deploy user experience assessment tools while playing the game to evaluate the user experience level. In the end, the teacher may discuss with students the results.

AUTHORS	Carlos Vaz de Carvalho (Virtual Campus)

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5 Conclusions

The HERA game, scenarios and support resources have been evaluated on many stages and different contexts. There were a lot of valuators from a vast variety of backgrounds, from engineering to economics. The feedback from the evaluation events and users was integrated into the software and support materials.

The game and scenarios provide a valuable material for teachers to develop soft skills among students. The project offers many different scenarios involving a variety of engineering and economic problems that can be used to raise awareness and practice skills such as communication, collaboration, problem-solving, etc.

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7 Appendix

7.1 Evaluation tools

7.1.1 Focus Group

Foreword

The focus groups were formed by groups of approximately 5 users. Focus groups generated input on a high level through informal feedback from students, probably more honest and direct than what quantitatively indicated in the questionnaires.

The objective of the focus group was to confirm, complement, or go in depth with specific aspects related to the platform and concerning the following indicators:

- Usability and UX.
- Technology.
- Engagement.
- Learning.
- Pedagogical aspects.
- Possible additional scenarios to be developed.

The analysis of the results of the focus groups benefitted from input generated through other evaluation tools, such as questionnaires and interviews.

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GUIDELINE QUESTIONS	FOCUS GROUP CONTENT
Usability/UX Objective: discover if HERA is easy and friendly to use. Examples of questions: ● *Do you think HERA is easy to use?* ● *What parts of the game are easier to learn and what parts are more difficult?* ● *How much time did you need to feel comfortable with the game?* ● *How do you think HERA could be clearer?* ● *Was gameplay fluid?* ● *Are game controls intuitive?* ● …	
Technology Objective: find out if there is something specific about the technology of HERA that users would like to comment. Examples of questions: ● *What do you think of the technology in HERA? Did it produce errors somewhere? If yes, where?* ● *Did you find the graphic interface captivating?* ● *What would you like to improve in the platform?* ● *Did HERA enable teamwork, or did you find any difficulty playing with your teammates?* ● …	

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Engagement Objective: understand if the platform is engaging for students. Examples of questions: ● *Did you feel personally engaged with the game?* ● *How do you think we could design a more engaging game?* ● *….*	
Learning Objective: understand if the platform is useful for learning. Examples of questions: ● *Do you think HERA encourages learning?* ● *Is the platform rich of learning content?* ● *Do you think the platform is useful to approach and learn something about engineering and/or economic subjects?* ● *Does HERA improve your problem-solving skills?* ● *Does HERA help you to have a holistic and multidisciplinary approach to a subject?* ● *…*	

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Pedagogical aspects Objective: discover if the platform stimulates a new didactic approach for learning. Examples of questions: ● *Does HERA stimulate problem-based learning?* ● *What possibilities can HERA have inside your study curriculum?* ● *Does it make sense to play several times?* ● *How is HERA related to the objectives, contents and activities of your courses and practices?* ● *Does the game motivate you to go on with your academic path?* ● …	
New possible additional scenarios *If you could create a new scenario, which one would you suggest?*	
Open question 1	
Open question 2	
Other comments by the interviewed	

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7.1.2 Interview

Foreword

Interviews must be carried out with the teachers involved in testing the platform together with their students. Interviews could take place just after the students finishes the test with HERA or in a following stage.

Interviews focus on the entire group of indicators already analysed using the questionnaires, but in a different degree and manner. They take advantage of the flexibility that it provides and adjust our questions to the specific experience of the teachers and go in depth with specific aspects we may be interested to discover.

GUIDELINE QUESTIONS	FOCUS GROUP CONTENT
Usability/UX Objective: discover if HERA is easy and friendly to use. Examples of questions: ● *Do you think HERA is easy to use by an average student?* ● *What parts of the game are easier to learn for your students and what parts are more difficult?* ● *How much time did your students need to feel comfortable with the game?* ● *How do you think HERA could be clearer?* ● *Was gameplay fluid?* ● *Did your students find problems with the game controls?* ● …	
Technology Objective: find out if there is something specific about the technology of HERA that users would like to comment. Examples of questions:	

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• *What do you think of the technology in HERA? Did it produce errors somewhere? If yes, where?* • *Did you find the graphic interface captivating?* • *What would you like to improve in the platform?* • *Did HERA enable teamwork, or did you find any difficulty playing with your teammates?* • *…*	
Engagement Objective: understand if the platform is engaging for students. Examples of questions: • *Did you see your students engaged with the game?* • *Did you feel personally engaged with the game?* • *How do you think we could design a more engaging game?* ….	
Learning Objective: understand if the platform is useful for learning. Examples of questions: • *Do you think HERA encourages learning?* • *Is the platform rich of learning content?* • *Do you think the platform is useful for your students to approach and learn something about engineering and/or economic subjects?* • *Could HERA improve your students' problem-solving skills?* • *Could HERA help students to have a holistic and multidisciplinary approach to a subject?* • *…*	

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Pedagogical aspects Objective: discover if the platform stimulates a new didactic approach for learning. Examples of questions: ● *Does HERA stimulate problem-based learning? Is it valid from a pedagogical PoV?* ● *What possibilities can HERA have inside your students' curriculum?* ● *Does it make sense to play several times?* ● *How is HERA related to the objectives, contents and activities of your courses and practices?* ● *Could the game motivate your students to go on with their academic path?*	
New possible additional scenarios *If you could create a new scenario, which one would you suggest?*	
Open question 1	
Open question 2	
Other comments by the interviewed	

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7.1.3 Questionnaire

Foreword

For the assessment of the product, please fill out the following questionnaire. It consists of 3 parts. All parts will have a 7-option answer, but the first part will be presented differently:

Example part 1:

attractive	○ ○ ○ ○ ○ ○ ○	unattractive

Example part 2:

		totally disagree	totally agree
n.	The game is addictive	👎 ○ ○ ○ ○ ○ ○ ○	👍

Please decide spontaneously and don't think too long about your decision. There is no wrong or right answer, just your honest opinion. If you are not completely sure about a particular attribute, please select a value anyway. Just tell us about your experience with the game!

Demographic information

Country

· Greece · Estonia · Portugal · Spain · Denmark

Knowledge area

- Business and economics
- Engineering
- Educational sciences
- Science
- Others

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Usability and user experience (UEQ-S)

obstructive	○ ○ ○ ○ ○ ○ ○	supportive
complicated	○ ○ ○ ○ ○ ○ ○	easy
inefficient	○ ○ ○ ○ ○ ○ ○	efficient
confusing	○ ○ ○ ○ ○ ○ ○	clear
boring	○ ○ ○ ○ ○ ○ ○	exciting
not interesting	○ ○ ○ ○ ○ ○ ○	interesting
conventional	○ ○ ○ ○ ○ ○ ○	inventive
usual	○ ○ ○ ○ ○ ○ ○	leading edge

Engagement

E1	I lost track of time	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-F25 N1
E2	I enjoyed playing the game	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-P20
E3	I felt skilful / competent	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-C02/10
E4	I was deeply concentrated in the game	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-F28
E5	I felt that I could explore things	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-I19
E6	Gameplay is challenging	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-H26
E7	I was fast at reaching the game's targets	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-C21
E8	It felt like a rich experience	👎 ○ ○ ○ ○ ○ ○ ○ 👍	E-I30

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Learning and pedagogical aspects

E1	I learnt something	👎 ○ ○ ○ ○ ○ ○ ○ 👍	L2
E2	Teamwork is key to get good results	👎 ○ ○ ○ ○ ○ ○ ○ 👍	-
E3	The game represents well real-life situations	👎 ○ ○ ○ ○ ○ ○ ○ 👍	L4
E4	The game improved my problem-solving skills	👎 ○ ○ ○ ○ ○ ○ ○ 👍	L5
E5	The game encompasses different learning subjects into one	👎 ○ ○ ○ ○ ○ ○ ○ 👍	PA2
E6	I feel motivated to learn other disciplines	👎 ○ ○ ○ ○ ○ ○ ○ 👍	PA4
E7	The game helped me to understand how to define problems and find solutions	👎 ○ ○ ○ ○ ○ ○ ○ 👍	PA1
E8	The game allowed me to work with my teammates	👎 ○ ○ ○ ○ ○ ○ ○ 👍	-

Free comments (open question)

1. What I liked more in the game was…
2. What I liked less in the game was...
3. The game would be better if…
4. If I could add a scenario, it would be…

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