Electronic, didactic and innovative platform for learning based on multimedia assets

e-DIPLOMA

Funded by the European Union

D.3.5 Testing and piloting conclusion report

Version 1.4

16 April 2026

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2. Table of Contents

3. Introduction

Testing and piloting the e-DIPLOMA prototypes was conducted as indicated in Table 1. The deliverable provides a summary report of testing at piloting sites.

Table 1. Overview of the piloting sites

Prototype	**Piloting countries**
Prototype 1. Block programming	Spain (UJI), Hungary (BME), Cyprus (CSI)
Prototype 2. Social entrepreneurship	Hungary (BME), Estonia (TLU), Italy (ARIS)
Prototype 3. VR	Spain (UJI), Hungary (BME), Cyprus (CSI)

In the pilots the ethical and data management regulations were followed. The following sections provide a summarised overview of each pilot organised according to the prototypes. The reports were qualitatively collected from each piloting partner, and are providing the organisers' view to the pilots based on their observations, communication with the learners in the testing rooms and their generalization reports. This report does not comprise direct qualitative information collected from the learners. The learner-level evidence is reported in D5.3 (the usability testing of the prototypes 1-3, conducted before the pilots) and D5.5 (Piloting results). The usability testing phase involved a small sample of a total of 10 participants, 5 men and 5 women, from 21 to 45 years. In the usability testing period the SUS scores and qualitative data were collected through the Thinking Aloud methodology and questionnaires (for more details see D.5.3).
In the end of the deliverable we summarise the main observational findings and the reached sample numbers in the pilots. In the Annex, Table 3 we provide the table that relates the piloting data that was collected from the pilot organisers observations with the learner data. It also provides a short overview of the technical corrections of the prototypes.

4.Testing and piloting Prototype 1

1. General information	
Piloting organisation	UJI
Prototype name	Block Programming and Electronics
Piloting period	Control condition: 13.01.25 - 12.03.25 Experimental condition: 04.02.25 - 12.03.25
Where did piloting of the prototype take place	Universitat Jaume I One room was used for each condition. One participant was housed per room.
How were the participants recruited?	Participants were recruited via email and through contact networks in the university community and local businesses. Participation was encouraged through social media campaigns, as well as through contact networks, and participation was voluntary.
Number of participants who started/finished each module (please fill for each module in the prototype)	*Experimental Group* *M1 (24)* *M2 (24)* *M3 (24)* *M4 (24)* *M5 (24)* *Control Group* *M1 (24)* *M2 (24)* *M3 (24)* *M4 (24)* *M5 (24)*
Who were the participants? (students, other groups)	Students, trainers (with different backgrounds), and developers
How were participants supported during the pilot?	Participants in both the control and experimental groups were supervised by a UJI staff member.
What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot)	

On some occasions, during the execution of module 5, there were some server synchronisation problems which forced the experimenter to restart the game frequently. That was fixed appropriately. Other technical problems were coincidental, due to compatibility with a certain computer hardware associated with the display port, that issue was fixed replacing the pc with another with the required features.
What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.) M1 Users quickly understood the content. M2 Users engage and have fun with the VR while they practise the learned content. Even users who had never programmed before quickly acquired the knowledge and demonstrated it with correct solutions during practice. M3 Users understood the content. M4 It was a way to reinforce their recently acquired knowledge in a didactic way. M5 It helped users better understand concepts they hadn't fully grasped. It built communication and teamwork skills. I was struck by the fact that some users who had never taken any programming classes found solutions even faster than those who had programmed before. They demonstrated confidence in solving problems as a team.
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) M1 (No issues found) M2 Users who had no prior experience with the technology took a little longer to adapt to the environment. M3 (No issues found) M4 Since the theoretical content is more related to memorization, it was more difficult for them to complete it correctly. M5 During the game, the user sometimes asks questions or clarifications about the theory or asks to be reminded of the rules of the game.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. The future use of prototype 1 at the UJI is considered potentially sustainable, especially thanks to the positive response from participants and the interest of faculty members in incorporating this type of application into their classrooms. The educational value of the activities and the engagement observed during the pilot suggest that the prototype can be a useful complement to traditional teaching methods, especially in STEM-related disciplines. However, the current VR infrastructure is limited to research environments, and expanding it to traditional teaching would require additional investment and institutional support. To ensure the long-term sustainability and broader implementation of the prototype, it is necessary to invest in equipment and infrastructure that can be used in educational settings across different faculties. Additionally, training programs should be provided for instructors and technical staff to guarantee their autonomy in the use and maintenance of the system. The educational content also requires adaptation to suit different learning levels and should be integrated with the university's existing platforms, such as Moodle. Finally, technical improvements are needed to minimize issues related to server synchronization or hardware compatibility, as observed during the pilot.

To promote future use of the prototype, it is recommended to showcase pilot results and student feedback through university innovation forums and internal meetings to raise awareness and generate interest. Organizing workshops or demonstration sessions for teachers and departments interested in digital learning tools would help familiarize more faculty members with the prototype's potential. Additionally, applying for internal or external funding would support scaling its implementation. Collaborations with local schools, businesses, or STEM programs could broaden the prototype's impact and provide valuable external feedback. Finally, integrating the prototype into elective or laboratory courses where hands-on learning is essential would facilitate its incorporation into regular teaching activities.

1. General information	
Piloting organisation	CSI
Prototype name	Block Programming and Electronics
Piloting period	Both conditions: 14.03.25 - 03.04.25 This pilot consisted of three sessions of approximately one and a half hours duration, separated by a week. In the first session, participants performed M1 and M2 along with the corresponding questionnaires. In the second, M3, M4, and questionnaires were completed. In the last session, participants completed M5 and questionnaires.
Where did piloting of the prototype take place	Location: CSI facilities and Alexander College. In both cases, two different rooms were used to house the participants in the control and experimental conditions separately. There were a maximum of two participants in the same room at a time. Participants in the experimental group were provided with a computer, headsets, virtual reality glasses and tablets in addition to the devices for bio measurements. Participants in the control group were provided with a computer, tablets, and printed material.
How were the participants recruited?	CSI established a collaboration with Alexander College in Larnaka, Cyprus. The collaboration included hosting our research team in their premises as well as sharing an open call to their students and educators, as software developers. The call included all the necessary information the participants need to understand the scope of the research and what is expected of them. Those interested must

	book their preferred slots from the website: https://simplybook.it/. After that, a CSI team member contacts them via email to send them their credentials to log in to the Moodle Platform.
Number of participants who started/finished each module (please fill for each module in the prototype)	*Experimental Group* *M1 (20)* *M2 (20)* *M3 (20)* *M4 (20)* *M5 (19)* *Control Group* *M1 (24)* *M2 (24)* *M3 (22)* *M4 (22)* *M5 (20)*
Who were the participants? (students, other groups)	Students, trainers (with different backgrounds), and developers
How were participants supported during the pilot?	Participants in both conditions were supervised by one person from UJI each. Additionally, a person from CSI has been present as support during the sessions.

What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot)

Because Module 5 is a collaborative activity that relies on a server connection, there were occasional connectivity issues at the start and during the activity. These issues sometimes required the activity to be restarted.

What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.)

M1- Since the videos were short and featured dynamic content, participants were able to maintain their attention during the explanations.
M2 - Participants were motivated to find the solution in the shortest time possible. All of them developed the motor skills necessary to complete the proposed exercises. Most were able to provide the correct solution to all exercises within one to three attempts.
M3 - Since the videos were short and featured dynamic content, participants were able to maintain their attention during the explanations.
M4 - Participants noticed the advantages of seeing extra information overlapped on the real electronic components
M5 - The pairs who collaborated effectively learned to use complex structures to successfully progress in the game and enjoyed the activity. They supported each other by identifying and correcting

possible mistakes made by their partner. Those who initially took longer to complete the knowledge pre-test exercises were able to reach a solution more quickly after participating in the activity.
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) In general, although there is an overview explanation of the activities and the relationship between them in the course, participants do not relate the programming modules with electronic modules. M1 - No issues M2 - Although the videos in M1 explain how the different block-based programming instructions work, and the final video provides a step-by-step demonstration of an exercise similar to those in M2, most participants tend to make the same mistakes solved in the videos. This may indicate that participants do not acquire the expected knowledge after completing M1. M3 - No issues M4 - Those participants who had no prior knowledge of electronics were overwhelmed by the number of new concepts. Participants rarely read the component descriptions or reflected on their use. Instead, they attempted to guess the names of each component or recall them from memory. M5 - The majority of participant pairs were not actively engaged in collaboration and chose to progress through the game individually, despite the requirement to make decisions jointly during the activity. Although there were instructions explaining the procedure, participants needed to experiment at the beginning to understand how it worked. Several of them did not plan a strategy to complete the activity in the fewest number of rounds possible, which was the main objective.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. The future use of the prototype 1 at CSI is considered potentially sustainable, given the positive engagement of participants and the educational benefits observed during the pilot. However, to ensure wider adoption, the server connectivity infrastructure would need to be improved. Furthermore, it is necessary to strengthen the integration between the programming content and the electronic content, as some participants had difficulty understanding the connection between modules or lessons. To promote future use, it is recommended to organize additional training sessions for both students and educators, refine the course design to enhance content linkage, and showcase the benefits of collaborative learning activities through internal workshops and external partnerships with educational institutions.

1. General information	
Piloting organisation	BME
Prototype name	Block Programming and Electronics
Piloting period	controls: 2025-02-13 – 2025-04-15 experimental: 2025-02-12 – 2025-04-15
Where did piloting of the prototype take place	Budapest, BME building I, room IL407 (15 computers) for control IB312 (graphics lab, 4 computers with VR) for experiments There were three sessions, over three

	consecutive weeks..
How were the participants recruited?	In person in classes research group website Microsoft Teams groups university newsletter through the Hungarian Game Developers' Association phone calls to industrial partners reach out to teachers at another university with more of an art profile (METU) department mailing list
Number of participants who started/finished each module (please fill for each module in the prototype)	*control:* *M1 28 / 28* *M2 28 / 28* *M3 28 / 28* *M4 28 / 28* *M5 28 / 28* *experimental:* *M1 27 / 27* *M2 27 / 27* *M3 27 / 27* *M4 27 / 21* *M5 27 / 20*
Who were the participants? (students, other groups)	*university students from BME and METU* *teachers from BME and METU* *developers from industrial partners*
How were participants supported during the pilot?	There were at least two persons from BME staff present to help with the experimental sessions, and at least one experimenter for the control. We equipped the measurement electronics (EMOBIT), handed out tablets (for TMT), provided instructions to proceed with the test on Moodle and when to stop, and helped put on the headsets. We also answered any questions. We asked if they used these devices before, reminded them that they can stop any time, and asked them if they were feeling all right. We answered questions, in particular about technical difficulties.
What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot) M4 This module did not work properly with the tablets we initially had. We replaced the tablets, but the operation was still slow, and you needed to know that you have to wait a bit for glitches to disappear. We had double images and the AR markings sliding off view, in particular for the second (extra) part of the task. It was not always possible to match all labels in the first task.	

We had to manually input the participant ID in a menu. The app did not always register the click to save the ID, and it sometimes took half a minute of trying to save it. M5 There was a dedicated server used, maintained in Spain. The server was not, in practice, capable of handling more than one pair of users, so we had a lot of disconnection and restart events before that became clear. As pilots in Cyprus were also executed concurrently, we created a new server in Budapest. This required a new option in the server code provided by UJI to connect to this new server. It turned out that the use of this extra parameter interfered with saving data, which resulted in significant data loss. Also, the behaviour of the robots with respect to obstacles was not as expected. On one computer the avatar of the participant was placed significantly lower than expected and this caused issues during play. It was resolved by resetting the headset position calibration.
What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.) M1 There was no problem watching the video. M2 Participants enjoyed the activity, handled it as a challenge, and expressed that they found it an interesting experience. The animated car and movement was appreciated and enhanced immersion while providing a strong visual feedback, M3 There was no problem watching the video. M4 Some participants found the topic and the idea of AR intriguing. Some were strongly motivated to get a good score. M5 Intensive cooperation and coordination happened between the pairs. Strategies were discussed. Participants were motivated.
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) M1 Some students with better background would attempt to speed up the videos (they were bored). M2 Some minor discomfort, dizziness, asking to sit down. M3 Some students with better background would attempt to speed up the videos (they were bored). M4 It was tedious and tiring to hold the tablet and work with it. Technical issues were discouraging. M5 Some fatigue.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. The knowledge level of the prototype is typically below the expertise of the computer science students at BME. However, the prototype can be used in promoting the University, and technical education in general, to secondary school students, for which we have a very active program. We will advertise the possibility to use this prototype through these channels.

5. Testing and piloting Prototype 2

1. General information	
Piloting organisation	BME
Prototype name	Social Entrepreneurship
Piloting period	controls: 2025-02-13 – 2025-04-15 experimental: 2025-02-12 – 2025-04-15
Where did piloting of the prototype take place	Budapest, BME building I, room IL407 (15 computers) for control IB312 (graphics lab, 4 computers with VR) for experiments There were two sessions, one in the morning and one in the afternoon, with a pizza lunch break in between.
How were the participants recruited?	in person in classes research group website Microsoft Teams groups university newsletter through the Coalition of Social Enterprises in Hungary department mailing list
Number of participants who started/finished each module (please fill for each module in the prototype)	*control:* *M1 18 / 18* *M2 18 / 18* *M3 18 / 18* *M4 18 / 18* *M5 18 / 18* *experimental:* *M1 22 / 22* *M2 22 / 20* *M3 18 / 16* *M4 22 / 22* *M5 22 / 22*
Who were the participants? (students, other groups)	*university students from BME* *teachers from BME* *social entrepreneurs*
How were participants supported during the pilot?	There were at least two persons from BME staff present to help with the experimental sessions, and at least one experimenter for the control. We equipped the measurement electronics EMOBIT), handed out tablets (for TMT and AR), provided instructions to proceed with the test on Moodle and when to stop, and helped put on the headsets. We also answered any questions. We asked if they used these

	devices before, reminded them that they can stop any time, and asked them if they were feeling all right. We answered questions, in particular about technical difficulties.

What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot)

M1 Clicking the markers was not always easy. Wrong calibration of the VR headset could result in the users located in weird positions in the virtual space. It was possible to click markers from the conversation space, changing the conversation, but making the order and number of conversations performed confusing.

M2 Sometimes it took more time for every client to connect, taking away from the effective activity time. Controllers sometimes malfunctioned.

M3 The Teams client could not always be started. Some accounts worked and some others did not, almost randomly.

M4 No problems..

M5 There were occasional glitches where cards did not behave properly, i.e. they could not be picked or played.

What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.)

M1 Participants enjoyed the exploration aspect. They were intrigued to discover criminals, or conflicts between the characters. Some groups had intensive idea sharing and discussions. Participants did not try to "game the system", they conducted targeted interviews, and the AIs never hallucinated incoherent details, or if they did they were not significant.

M2 There was some multiplayer cooperation, and those participants who understood the controls and the task, could coordinate strategies.

M3 The participants were engaged to discover the intricacies of energy sharing through conversation with different characters and discussions between themselves.

M4 The task was relatively easy to understand. Participants did conduct meaningful job interviews and assembled teams. There was a big variation of how successful the participants could be in assembling efficient teams. The operation of the social enterprise was well understood.

M5 There were big differences in how many points different participants could make, depending on their understanding of the game and strategies. People were motivated to find out more about efficient strategies.

What issues did you notice during the learning activity as the learning manager in the class? (please report for each module)

M1 The structure with each participant doing exactly two conversations was too constrained. Sometimes more, shorter conversations would have been preferred. The activity could definitely be longer, as there was way more content than what could be expired in the pilot timeframe.

M2 Some discomfort, nausea. Asking to stop after a while — but this typically happened at our near the end of the 15 min activity. Confusion with the controls. Some participants left out of the strategizing process by other, more active members. Some people had some AHA moment, seeing how things worked, but a lot of participants did not get to that point in the allotted time frame. While longer sessions would be too exhausting, repeated playthroughs of the game with breaks between them would be necessary for everyone to get comfortable with the controls and be able to try multiple strategies and make conclusions.

M3 The software setup was incredibly complex, with a virtual machine connection, separate Teams

and Edison windows. The Edison control interface was not something participants could learn to use in a few minutes, so heavy experimenter assistance was required. The technology thus could not really contribute to the experience, it was more of a hindrance. M4 Some participants needed assistance finding some controls and buttons, and to make sense of the markings. The user interface could be cleaned up a bit. Multiple playthroughs could enhance the understanding and the strategy aspect, but for this game the time frame was often enough for participants to create an efficient team. M5 There was not enough time to grasp all game mechanics, especially for users not experienced with board games. Playing only one session caused that some participants could not get familiar enough with the game during the experiment. Multiple playthroughs would definitely be needed to be able to compare strategies. More time to study the knowledge linked to the cards would be necessary.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. Social entrepreneurship is not exactly in the main profile of the Faculty of Electrical Engineering and Informatics. However, the material was approved as part of an elective course. Modules 1, 4, and 5 could be incorporated and/or adapted to existing economic courses, for which further cooperation between faculties and adjustment are necessary. The games can be offered as an elective experience for secondary school students visiting the university, which happens regularly as part of several initiatives. Module 2 is too equipment-intensive and tedious to use, and would need a bit of repurposing. We do not think we could use Module 3 in its current form, but the material that exists in the form of video and AI characters can be used.

1. General information	
Piloting organisation	Italy (ARIS)
Prototype name	Prototype 2 - Social entrepreneurship
Piloting period	03-07/02/202 + 13/02/2025– Experimental group 24-25/03/2025 + 27/03/2025– Control group
Where did piloting of the prototype take place	Experimental group: Computer Lab High school “I.I.S. Cavour Marconi Pascal” - Via Assisana 40/D, 06100 Perugia (PG) Control group: Computer lab high school “Licei Statali F. Angeloni - Viale Cesare Battisti”, 100, 05100 Terni (TR) Control group: ARIS formazione e ricerca, Strada Santa Lucia 8, 06125 Perugia (PG)

How were the participants recruited?	Participants for the pilot were identified through a structured selection process aimed at ensuring a representative and relevant sample across the target stakeholder groups. A total of 49 individuals took part in the pilot, equally divided between the experimental group (24 participants) and the control group (25 participants). The composition of the participant group included: 29 students, 10 trainers/educators/teachers, and 10 social entrepreneurs or experts in the field of social innovation. The recruitment of students was carried out in collaboration with two secondary schools: "Licei Statali F. Angeloni" in Terni and "I.I.S. Cavour Marconi Pascal" in Perugia. These schools are long-standing partners of ARIS, with which formal cooperation agreements are in place for the implementation of European educational and training projects. Students were selected based on their engagement in innovation-related educational tracks and their availability to participate in the pilot activities. Trainers, educators, and teachers were selected from ARIS's internal network of professionals regularly engaged in the organization's training programmes. This network consists of qualified personnel with prior experience in formal and non-formal education, thus ensuring a high level of pedagogical competence and relevance to the project's thematic areas. Finally, the social entrepreneurs and experts were identified from among ARIS's network of members, which includes approximately 50 organizations, such as social cooperatives and social enterprises operating in the Umbria region. Selection criteria included expertise in social innovation, active involvement in community-based initiatives, and interest in participating in co-design and pilot testing processes. This diversified recruitment strategy ensured a balanced and context-relevant pilot implementation, with active engagement from all key stakeholder groups
Number of participants who started/finished each module (please fill for each module in the prototype)	M1 - 24/25 M2 - 24/25 M3 - 24/25 M4 - 24/25 M5 - 24/25

Who were the participants? (students, other groups)	29 students, 10 trainers/educators/teachers, and 10 social entrepreneurs or experts in the field of social innovation
How were participants supported during the pilot?	During the pilot phase, participants received structured and differentiated support tailored to their respective groups to ensure effective engagement with the project objectives and tools. An initial introductory session, lasting approximately 90 minutes, was conducted for all participants. For students, this session was held in person in the classroom, while for other participant groups, the session took place online. The session served to present the overall structure of the project, including its main objectives, the involved partners, the expected outcomes, and an overview of the developed prototypes. This initial orientation aimed to ensure that all participants shared a common understanding of the project's scope and were adequately prepared to engage with the subsequent phases of the pilot. Throughout the pilot activity, participants in the experimental and control group benefited from dedicated in-person support. Specifically, ARIS provided a classroom tutor who was present for the entire duration of the piloting. This tutor played a crucial role in offering real-time guidance and support to both students and other participants involved in the pilot implementation. The presence of the tutor ensured that any technical or procedural issues could be promptly addressed, thereby maintaining the continuity and quality of the pilot activities. Additionally, BME contributed to the pilot by assigning two researchers to the project. These researchers were responsible for the design and development of the educational modules and oversaw the technical implementation of the pilot. Their involvement ensured a high level of technical accuracy and responsiveness, particularly with respect to the deployment and operational functionality of the digital tools and content used during the pilot. Overall, the combined efforts of ARIS and BME, along with the structured onboarding of participants through the introductory sessions, created a robust support framework that facilitated smooth participation, enhanced user experience, and enabled the effective collection of feedback for further refinement of the project outcomes.

What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot) During the setup and execution of the e-DIPLOMA technology prototype, no major technical issues were encountered that affected the overall implementation of the pilot protocol. The system functioned as expected, and all planned activities were successfully carried out. The only minor issues occurred during the recovery session for the experimental group, held on February 13, 2025. On that occasion, there were some initial connectivity problems with the EMOBIT device. However, this did not impact the core progress of the pilot, as the recovery session was focused on the second part of the experimental activities—specifically Modules 3, 4, and 5—which did not require the use of EMOBIT. Additionally, the TMT (Trail Making Test) initially experienced some connection issues during the same session. These issues were promptly resolved, and all participants were able to complete the pilot activities without further complications. All data from the session were successfully collected and saved. Despite these minor technical difficulties, the session was completed as planned, and the overall pilot remained on schedule and within protocol.
What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.) Mod. 1: One of the main strengths observed was the high level of interaction facilitated by the use of avatars in Augmented Reality (AR). Participants quickly became familiar with how to use AR technologies and interact with the embedded chatbot. The intuitive design allowed users to engage with the system effectively, fostering active participation from the outset. The interactive experience supported the development of digital skills while enabling learners to comfortably navigate mixed reality environments. Mod. 2: In this module, participants demonstrated growing confidence in using AR. They actively engaged with the scenario and were able to observe how the environment dynamically responded to their decisions. This cause-and-effect mechanism reinforced experiential learning and decision-making. The visual and interactive aspects of the AR environment contributed to a deeper understanding of the content by enabling participants to directly perceive the consequences of their actions within a simulated context. Mod. 3: This module showcased the potential of AI-driven dialogue in enhancing critical thinking. By interacting with avatars trained on different datasets and perspectives, participants were able to explore how responses to the same question can vary depending on the underlying values or point of view. This stimulated reflection on bias, interpretation, and the influence of diverse knowledge bases, offering a concrete example of how AI systems process and generate responses. The exercise was particularly valuable in promoting media literacy and awareness of AI-driven content generation. Mod. 4: Participants reported feeling a strong sense of responsibility when placed in the role of entrepreneurs within the simulation. The game-based structure encouraged them to make strategic choices aimed at achieving specific objectives, reinforcing skills such as planning, resource management, and goal orientation. The immersive format enabled learners to take ownership of their decisions, simulating real-world problem-solving in a safe, controlled environment. Mod. 5: Despite the limited time available to fully learn the rules of the game, participants were highly motivated to perform well and maximize their scores. This competitive aspect of the module encouraged engagement and perseverance. Participants demonstrated a proactive attitude, working to understand the mechanics quickly and apply them efficiently. The module fostered adaptability and fast learning, as users navigated new tasks under time constraints.

What issues did you notice during the learning activity as the learning manager in the class? (please report for each module)
Mod. 1: While the interaction with avatars was generally effective, some of the responses provided by the system were perceived as too repetitive, limiting the opportunity for deeper exploration of the topic. For participants already familiar with the concept of social entrepreneurship, the time allocated for each interview felt excessive, potentially reducing engagement for more experienced users.
Mod. 2: One of the key challenges in this module was the lack of immediate clarity regarding the impact of participants' decisions when selecting and placing the building blocks. The visual changes in the scenario did not always clearly convey whether the outcomes of their choices were positive or negative, which may have reduced the perceived relevance of decision-making and limited learning reinforcement.
Mod. 3: This module involved interaction with an AI avatar and collaboration via Microsoft Teams to explore the topic of renewable energy communities. A major issue was the complexity of managing two digital interfaces simultaneously. Participants found it cumbersome to switch between the AI interface and Teams. Additionally, since all participants were physically located in the same room and in close proximity, the collaborative potential of Teams was not fully realized. The interaction felt less dynamic and redundant in the shared physical context.
Mod. 4: The simulation focused on the circular economy of used goods required participants to make strategic decisions to improve business performance. However, without a clear understanding of the entire supply chain beforehand, many participants struggled to identify how their actions could effectively improve outcomes. This gap in prior knowledge made it difficult to plan and optimize their decisions throughout the module.
Mod. 5: The final module introduced a competitive game-based activity, but the rules were complex and difficult to grasp in the short time available. This led to a sense of frustration among several participants, as many were unsure about how to play or maximize their score. The limited time for familiarization with the mechanics negatively affected engagement and learning outcomes.

How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype.
ARIS is a vocational training center with a strong focus on the social sector. In this context, the e-DIPLOMAprototype shows promising potential for sustainable use, especially as a tool to introduce and explain the principles and mechanisms of social innovation and social entrepreneurship. Its interactive and gaming-based approach makes it particularly suitable for engaging younger learners aged 16–25, especially those pursuing an EQF Level 5 qualification.
The prototype could be effectively integrated into ARIS's training offerings as part of workshops, showcase events, or specialized modules aimed at promoting awareness of the social economy and the role of technology in driving innovation. It can also be valuable for learners who are approaching these topics for the first time, offering an accessible and engaging entry point through simulation and interaction.
One potential limitation is the varying level of digital skills among target users, which could present challenges in navigating some of the more complex modules. However, the gamification elements embedded in the prototype may help mitigate this issue by creating a more intuitive and motivating learning experience that supports digital competence development as a secondary outcome.
To promote future use, ARIS could implement the prototype in pilot courses focused on digital tools for social innovation, involve local stakeholders through demo sessions, and collaborate with networks in the social economy to disseminate the tool. With appropriate guidance and support, the prototype could become a sustainable part of ARIS's training methodology.

1. General information	
Piloting organisation	Tallinn University
Prototype name	Prototype 2 - Social entrepreneurship
Piloting period	Test group: 10.01 - 18.01.2025. Control group: 10.01 - 31.03.2025 Each person in the pilot was present during one day for learning the whole prototype and answered the questions. There was a break in between the modules when lunch was offered.
Where did piloting of the prototype take place?	Location: Tallinn University Testing group: in the room that was specifically organised for the pilot. The room was equipped with the stand alone computers, VR glasses, tablet, measuring equipment Control group: A separate classroom with laptop computers was provided, there was no tablet for TMT test in some cases
How were the participants recruited?	Participants were recruited from different student and professionals networks
Number of participants who started/finished each module (please fill for each module in the prototype) (based on consents and system data)	*Experimental group* *M1 24/24* *M2 24/24* *M3 24/24* *M4 24/24* *M5 24/24* *Control group* *M1 24/24* *M2 24/24* *M3 24/24* *M4 24/24* *M5 24/24*
Who were the participants? (students, other groups)	Students, educational technologists, lecturers
How were participants supported during the pilot?	The Test group was supported by 2 technical moderators from the partner university of Hungary who helped with VR and measuring devices and guided the modules procedurally. Both in the test group and control group the TLU facilitators from the team were at present who guided the learning and measurement process.
What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot) Access to e-DIPLOMA Moodle was down for an hour in one day. Not all the data from physiological measures were recorded technically. For some participants some of the modules were locked.	

One provided user account was not attached (not enrolled) with the prototype.
What pros did you see learning with this prototype in the test group? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view) M1. The participants were able to exercise their skill to listen and ask the right questions in this module. Interviewing avatars with VR glasses while exchanging information with other group members helped the learners in refining their inquiries based on whether the input from group members or by observing other participants in the inquiry process. Collaborative approach aided the participants in their decision-making processes about whether a citizen is or is not a social entrepreneur. Participation in the learning task was more accessible, because this VR module did not cause any participants to feel ill (in comparison to M2) – the world building and motion were more stable. Immersion supported learning. M2. This module encouraged collaborative learning and communication of the participants as the task was to build a city that meets citizens' needs. Throughout the task, participants' individual actions needed to be complemented by the actions of other group members in creating new buildings, which encouraged collaboration. The task allowed participants to observe and respond to several factors representing the complexity of well-being in cities (living spaces, health facilities, food and entertainment options, accessibility). Immersion and ability to hear others from the headset supported learning. M3. Participants' ability to ask the right questions and receive relevant information was developed while chatting to a chatbot. M4. Development of fast decision-making and responding to changing team dynamics. Clearly structured game environment with well visualised information that enabled participants to observe changes of the situation. M5. Participants were able to learn about the importance of segmentation, marketing and other thematic elements once they understood the game. Written instructions supported the learning process as well as the video shown beforehand.
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) Confusion with the tasks, distress of not coping technically. People had some health concerns - fatigue, dizziness *M1* - Distress of not coping technically, People had some health concerns - fatigue, dizziness *M2* - People had some health concerns - fatigue, dizziness. Visualisation of the influx of citizens was unclear (bubbles with symbols were grainy and hard to decipher). *M3* - Edison platform was not intuitive and people kept erasing the business canvas. In the end, the moderator of the pilot took control, removing agency from the group. The type of the business enterprise was unclear. Navigating between Edison and Teams created more complexity and put focus on the technical side of the module. Recording from Teams sometimes created an echo to the conversation, creating unnecessary cognitive load. *M4* - Confusion with the tasks, time pressure. It was unclear how the points were collected during the game. *M5* - Confusion with the tasks, a lot of external guidance was needed in order to understand the goal of the board game as well as consequences of each action players needed to take. The size of game elements could have been bigger – participants had trouble seeing the elements from the screen.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. Tallinn University does not have the VR facilities. The technology was borrowed for the pilot settings. The prototypes need to be translated. It could be used in the master curriculum of Social Entrepreneurship.

6. Testing and piloting Prototype 3

1. General information	
Piloting organisation	CSI
Prototype name	VR for education
Piloting period	Both conditions: 18.03.25, 04.04.25 - 08.04.25
Where did piloting of the prototype take place?	Location: CSI facilities and Alexander College. In both cases, two different rooms were used to house the participants in the control and experimental conditions separately. There were a maximum of two participants in the same room at a time. Participants in the experimental group were provided with a computer, headsets, and virtual reality glasses in addition to the devices for bio measurements. Participants in the control group were provided with a computer and headsets.
How were the participants recruited?	CSI established a collaboration with Alexander College in Larnaka, Cyprus. The collaboration included hosting our research team in their premises as well as sharing an open call to their students and educators, as software developers. The call included all the necessary information the participants need to understand the scope of the research and what is expected of them. Those interested must book their preferred slots from the website: https://simplybook.it/. After that, CSI team member contacts them via email to send them their credentials to log in to the Moodle Platform.
Number of participants who started/finished each module (please fill for each module in the prototype)	*Experimental Group* *M1 (23)* *M2 (22)* *M3 (18)* *M4 (14)* *M5 (9)* *Control Group* *M1 (19)* *M2 (19)* *M3 (19)* *M4 (19)* *M5 (17)*
Who were the participants? (students, other groups)	Students and trainers (with different backgrounds)

How were participants supported during the pilot?	In each room, there was a representative from UJI ensuring that the entire pilot process was followed correctly and assisting participants with any questions. They helped participants put on all the necessary hardware and provided support when they encountered difficulties. Additionally, a representative from CSI was always available to provide support.
What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot) The activities cannot be carried out independently, as the tasks are not separated by lectures. There must always be someone indicating when the activities for a given lecture are completed. It is also common for the VR application to close unexpectedly. Sound from theoretical videos was really low.	
What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.) M1 - Most participants are able to complete the tasks in this module without significant difficulties. Tech-savvy people find the module activities interesting and fun. M2 - Those who were able to complete the activities found them enjoyable. M3 - Some users with prior knowledge of the subject, especially teachers, were able to recognize the potential usefulness of the VR module or lesson, especially if it were adapted to specific teaching content. M4 - Some users with prior knowledge of the subject,especially teachers and content creators, were able to recognize the potential usefulness of the VR module in their lesson. M5 - Some users identified the potential of the VR simulation module to represent physical phenomena, offering an interactive environment where they could explore different configurations and better assimilate the educational content.	
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) In general, it is necessary to have someone supervise the learner at all times, as, despite the explanations on how to use the controls and the objectives of the tasks, they often feel lost and unsure of how to proceed. M1 - Although all participants are able to complete the six tasks in this module, many do not acquire the motor skills being practiced, as in later modules, when this type of interaction is required, they are unsure of how to perform it. M2 - The vast majority of participants experienced dizziness and nausea, which prevented them from continuing with the practice. Many did not develop the motor skills necessary to successfully complete the exercises and did not understand the objective. M3 - Participants often did not read the activity instructions, which led to a lack of understanding of their purpose. They found it very difficult to successfully complete the last two steps of the activity. Although they had learned to interact and navigate the environment in previous modules, most of them did not apply these skills in this activity, despite them being necessary. M4 - In general, users did not remember the control dynamics they had just learned in previous	

lessons. Therefore, it is necessary to review and restructure the lesson content, the time allocated for learning, and the connection or narrative thread between lessons in order to address this issue. M5 - In general, users did not remember the control dynamics they had just learned in previous lessons. Therefore, it is necessary for the experimenter to constantly remind users about the use of the dynamics of the controls, specifically during the final project, which consisted of building a virtual museum. This final activity has no textual instructions for the tester user. For this reason, the experimenter must constantly explain to the user how to use the application.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. Future use of prototype 3 in CSI is considered challenging in its current form, primarily due to the high need for constant supervision, frequent technical issues, and user difficulty navigating and understanding activities independently. To achieve sustainable use, it would be necessary to improve the app's stability, more clearly separate learning modules, optimize teaching materials, and minimize the effects of motion sickness. To promote future adoption, specific improvements based on pilot feedback should be implemented, instructor training sessions should be organized, and pilot success stories highlighting the benefits for tech-savvy participants should be presented to generate interest among educators and students.

1. General information	
Piloting organisation	UJI
Prototype name	VR for education
Piloting period	25/02/2025-15/04/2025
Where did piloting of the prototype take place?	Location: INIT- UJI facilities. One room was used to house the participants in the experimental group. One participant at a time. Participants in the experimental group were provided with a computer, headsets, and virtual reality glasses in addition to the devices for bio measurements. Participants in the control group take the course online.
How were the participants recruited?	Participation was encouraged through social media campaigns, in addition to contact networks, and participation was voluntary.
Number of participants who started/finished each module (please fill for each module in the prototype)	*Experimental Group* *M1 (19)* *M2 (23)* *M3 (23)* *M4 (23)* *M5 (23)* *Control Group*

	M0 (20) *M1 (19)* *M2 (20)* *M3 (19)* *M4 (20)* *M5 (19)*
Who were the participants? (students, other groups)	Students, trainers (with different backgrounds), and content creators.
How were participants supported during the pilot?	During the pilot, each participant was assisted by an experimenter who had been previously trained in the use of VR technology. The experimenter provides a brief introductory overview of the course to the user and guides them on how to use the course on Moodle. The experimenter supports the user throughout the entire pilot process: from the preparation of the experimental setup as described in the corresponding protocol, to the configuration and calibration of the VR equipment. They remain attentive at all times to when each of the VR games associated with the five learning modules should start or end. Additionally, they guide and assist the participant whenever they have doubts about how to use the technology or do not fully understand the objective of the activity. The experimenter also ensures that the user feels safe during the various sensations that may be experienced with VR and makes sure they do not collide with any obstacles in the physical environment. The final project in module 5, unlike the rest of the modules, does not provide instructions to the user, so the experimenter has to intervene and explain to the user how the tool works.
What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot) The modules for each lesson were not separated independently. Therefore, it was necessary for the experimenter to force the game to stop when it did not correspond to the corresponding lesson. Some participants accidentally closed the game while using the controllers, so the experimenter had to reopen it. In simulation module 5, there were some problems with the left controller controls. The dynamics of this controller caused the user to begin moving around the virtual world without having initiated it, so the experimenter had to turn off the left controller and restart the game.	

One day the application did not function in the local computer, maybe because of Windows OS actualization, so the action taken was to install the prototype and hardware in another computer. The second day the application was working normally on the first computer.
What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.) From a didactic point of view, users generally seemed motivated to carry out the practical activities with VR. It was possible to notice progress in the use of VR dynamics and controls only among users with no prior experience, as those who were already familiar with VR mastered it easily. They normally enjoy the experience with VR. Some users told me they enjoyed the course. Two teacher-type users told me they would like to include this type of VR lesson in class. One user mentioned to me that this pilot could be useful as an introductory class to VR for people who are not accustomed to using it. M1 - In the case of users who had never used virtual reality or had little experience with it, this module helped them learn how to use the object interaction controls, and in general, they retained that newly acquired skills. M2 - The users generally acquire skills in the use of controls and dynamics. M3 - Some teachers who teach subjects related to this field said they liked the module and would like to incorporate this type of content into their classes. M4 - Some users with prior knowledge of the subject, especially content creators, recognized the potential of the VR module as a valuable tool for enhancing their teaching. M5 - Users showed great interest in simulating the physical conditions of objects on different planets. Therefore, this module can be an ideal complement to theoretical physics or mathematics classes.
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) The main issue was that some users who haven't used the VR headset before experience dizziness and fatigue in module 2, causing them to be unable to complete it. Furthermore, the dizziness lasts for the entire session. On the other hand, the VR games provided all the instructional information in textual form, which was sometimes lengthy. As a result, I noticed that some users would occasionally forget certain details of the instructions or didn't fully understand how to use the controls. This required the experimenter to intervene frequently, giving them directions or explaining how to use the controls to complete the objective of each game level. Additionally, as the experimenter, I had to be constantly alert to ensure they didn't bump into physical objects (like the table or computer screen) or get tangled in the VR headset cables. Sometimes the experimenter realizes that the user does not understand the learning objective of the course. Moreover, during the theoretical lessons, most users asked the experimenter questions about the meaning of some acronyms used in the knowledge questionnaires that were not defined in the theoretical content or in the VR application, and they commented on some typos in the text of the questionnaires. Users considered this to be useful feedback. M1 - Sometimes the experimenter has to explain to the user how to use the controls, even though it is explained in the text. M2 - In Module 2, several users unfamiliar with VR technology experienced dizziness and nausea, and the game had to be stopped. Afterward, two users felt disoriented and told me they had somewhat lost

track of what they were learning; they were fatigued by the length of the course. I noticed that users with less VR experience took much longer to achieve the activity objective, the activity took longer, and the experimenter had to intervene frequently to help them achieve the exercise objective within the allotted time, as they found themselves in a loop and needed guidance to prevent frustration. Additionally, users begin to experience motion sickness starting with the second activity in this module, and this worsens with the third and final activity, where the flying option is added. Some users commented that this activity should be optional and that the user should decide whether to do it or not. M3 - The user often gets stuck trying to place the light bulb in the exact spot the app determines to advance to the next level. Users generally don't remember that they can move in space the way they were taught in other modules, so the experimenter reminds them. M4 - I usually have to remind the user how to move around the museum. M5 - This module has no textual instructions for the tester user. For this reason, the experimenter must constantly explain to the user how to use the application. Without prior instructions, it is an application that is not very intuitive for the end user unless they first read the full game instruction manual. Furthermore, completing this activity would require much more time than the time allotted for piloting. Users generally don't remember that they can move in space the way they were taught in other modules, so the experimenter reminds them. I noticed that teacher-type users who had never used VR and were older than the average age were more reluctant to explore new actions with the controllers.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. The future use of the VR for Education prototype at UJI is considered potentially sustainable, especially due to the positive feedback received from participants and the interest shown by teaching staff in incorporating similar activities into their classrooms. However, current VR infrastructure is limited to research environments, and its expansion into regular teaching settings would require additional investment and institutional support. Moreover, it is necessary to improve some aspects. First, it is necessary to improve user autonomy. The current version of the prototype requires constant support from an experimenter. For wider deployment, the system should include more intuitive interfaces, clearer instructions (both textual and visual/audio), and optional tutorial modules to reduce dependency on human guidance. Secondly, continued access to functional VR hardware, technical support, and spaces adapted for VR use is essential. Third, a training program for teachers and facilitators would be needed to scale up usage. Last but not least, fixing usability issues, reducing motion sickness in certain modules, and adapting the content to broader learning contexts will help integrate the prototype more widely into curricular activities. To promote its future use, it is recommended to improve user autonomy within the application and refine the content, both to adapt it to the needs of a real course and to reduce the cognitive load on students. Collaboration with faculty interested in immersive learning is essential to pilot the prototype in real academic environments. Finally, it would be useful to incorporate VR modules into elective or introductory courses for technology or pedagogy students.

1. General information	
Piloting organisation	BME

Prototype name	VR for Education
Piloting period	2025-03-03–2025-04-15
Where did piloting of the prototype take place?	Budapest, BME building I, room IL407 (15 computers) for control IB312 (graphics lab, 4 computers with VR) for experiments
How were the participants recruited?	in person in classes research group website Microsoft Teams groups university newsletter through the Hungarian Game Developers' Association phone calls to industrial partners and other online content providers and VR developers reach out to teachers at another university with more of an art profile (METU) department mailing list
Number of participants who started/finished each module (please fill for each module in the prototype)	*control:* *M1 29 / 29* *M2 29 / 29* *M3 29 / 29* *M4 29 / 29* *M5 29 / 29* *experimental:* *M1 25 / 21* *M2 25 / 25* *M3 25 / 25* *M4 25 / 25* *M5 25 / 19*
Who were the participants? (students, other groups)	university students from BME and METU teachers from BME and METU content creators from game development companies
How were participants supported during the pilot?	There were at least two persons from BME staff present to help with the experimental sessions, and at least one experimenter for the control. We equipped the measurement electronics (EMOBIT), handed out tablets (for TMT), provided instructions to proceed with the test on Moodle and when to stop, and helped put on the headsets. We also answered any questions. We asked if they used these devices before, reminded them that they can stop any time, and asked them if they were feeling alright. We answered questions, in particular about technical difficulties.

What technical issues did you notice during the setup and running of the e-DIPLOMA technology prototype? (Note. System usability report is about usability tests results D.5.3, here we ask about your observations as organizers of the pilot) In all modules, we experienced some random crashes initially, but these were reduced by a quick fix. Overall the entire prototype was very solid. A configuration issue caused the second part of the very last module to partially fail initially but these were quickly fixed. It only resulted in a minor data loss and that the affected participants could not "walk" in the final labyrinth (but they could still build it). The activity did not close itself after a module ended but continued with the next one. This sometimes caused that the students who did not recognize that they had finished the module to continue with the next until the experimenter took notice and terminated the activity manually.
What pros did you see learning with this prototype? (please report for each module) (Note that D. 5.3 will present all evaluation results from the learning point of view.) M1 The module was very didactic, taking the learners through steps. More experienced participants were faster, but everyone could understand the tasks. M2 Was challenging and offered an experiential way of comparing various navigation methods.. M3 Again well designed, incremental steps, tasks were easy to understand. M4 Some interesting and surprising tasks. M5 A sandbox type experience where the most interested participants comfortable with the technology could spend additional time experimenting.
What issues did you notice during the learning activity as the learning manager in the class? (please report for each module) M1 some activities were more challenging if the physical space was limited (bumping into real obstacles when manipulating the VR world) M2 some navigation modes were prone to induce dizziness and nausea for several participants. There were situations where sheep had to be chased along a fence, which not everyone got on to, and when they did, it was an exhausting task. Some popular navigation modes were missing like emulating running with hands or dragging themselves in the environment. M3 was especially demanding on computers, and scattered motion and slower reaction times occurred on at least one of our computers. This made it less comfortable and more challenging to perform the tasks. M4 This was the module where the tasks were least clearly linked to actual practical applications. They were somewhat repetitive with no clear reason why something has to be done multiple times, and some parts were easy to skip. M5 Not all participants were interested in free exploration, and finish this activity quickly. Much of this can be attributed to fatigue.
How sustainable is the future usage of this prototype in your university? How to promote the future use of the prototype. The prototype is a solid introduction to using VR in general. BME has used it, and will continue to use it to introduce university students, university professors, as well as visiting secondary school students to VR basics. The prototype can be streamlined or personalized in places, depending on the interest of the student, and without the pilot instrumentation it will require much shorter time to execute and introduce less fatigue.

7. The summary of the piloting process

Table 2. The summary of piloting process participants

Prototype number	Pilot+Control group (N total, % of expected)	Pilot group (N/Total)	Control group (N/Total)
P1 Module 1	145 (96%)	24; 28; 20/ 70	24; 27; 24 / 75
P1 Module 2	145 (96%)	24; 28; 20/ 70	24; 27; 24 / 75
P1 Module 3	143 (95%)	24; 28; 20/ 70	24; 27; 22 / 73
P1 Module 4	137 (91%)	24; 28; 20/ 70	24; 21; 22 / 67
P1 Module 5	134 (89 %)	24; 28; 20/ 70	24; 20; 20 /64
P2 Module 1	137 (91%)	24; 18; 24 /66	24; 22; 25 /71
P2 Module 2	135 (90 %)	24; 18; 24 /66	24; 20; 25 /69
P2 Module 3	131(87%)	24; 18; 24 /66	24; 16; 25 /65
P2 Module 4	137 (91%)	24; 18; 24 /66	24; 22; 25 /71
P2 Module 5	137 (91%)	24; 18; 24 /66	24; 22; 25 /71
P3 Module 1	135 (90%)	21; 19; 23 /63	29; 20; 23 /72
P3 Module 2	140 (93%)	25; 23; 22 /70	29; 19; 22 /70
P3 Module 3	133 (88%)	25; 23; 18 /66	29; 20; 18 /67
P3 Module 4	129 (86%)	25; 23; 14 /62	29; 19; 19 /67
P3 Module 5	116 (77%)	19; 23; 9 / 51	29; 19; 17 /65

In Prototype 1, 2 and 3 in each 150 persons were to be recruited. We reached lower numbers of participants (77-96%) than expected in the grant proposal (see Table 2). The recruitment was difficult because in each prototype the participants had to spend the whole day for the experiment. Also people were easier to be invited to the pilot with new technologies than to the test group with traditional e-learning.

Testing of the prototypes was completed with the delay compared with the project timeline. This was caused by the following issues: It was needed to arrange that the support team would travel to the location sites, so arrangement took more time than expected.

In summary, the technical issues in the testing of the prototypes were not large. In prototype 1 using tablets for pilots was causing the problems, in desktop computers it worked. In Prototype 1 module 5, that required virtual collaboration, the synchronization caused some technical issues and required a better server. In prototype 2 there were VR calibration issues to wrongly locate the learners in VR space, problems to click the markers, as well as starting the clients and using Teams were delayed. On that occasion, there were some initial connectivity problems with the EMOBIT device and the TMT (Trail Making Test). Not all the data from physiological measures were recorded technically. In prototype 3 VR applications sometimes closed unexpectedly. Sound from theoretical videos was low. Some data was lost.

The pedagogical aspects and issues could be summarised as follows (and will be looked more in depth in D. 2.1).

In prototype 1 the named learning merits were easy grasping what to do, understanding and applying the concepts in practice even for inexperienced in programming learners. Participants were motivated due to short tasks, they maintained their attention. The AR overlay text was considered helpful for problem solving with electronics. The animated car and movement was appreciated and enhanced immersion while providing a strong visual feedback. Many participants could collaborate effectively on problem solving strategies in the final module. Students considered good scores important in the modules.

In prototype 1 learners without prior experiences faced difficulties to understand how to use the technology, they lacked enough time and could not focus on learning. The participants were overwhelmed by too many concepts, and had difficulties to associate visually modelled and electronic connections. There was often a need for the support person to guide students about theoretical and learning scenario rules-related aspects in the modules. Participants did not read the guidance information as was supposed, but used trial and error method. The collaborative virtual problem solving did not work as well as expected, and ended up working more individually. Some students tried, however, to speed up videos, people felt bored and fatigued. Some dizziness was experienced.

In prototype 2 the gaming features motivated students, they liked interaction with AI virtual avatars, learning to use them and receive varied responses was intuitively explored. Students discussed strategies external from the VR settings extensively. The players with better coordination in VR were able to go at strategy level in the game and cooperate in a dynamic situated environment. Immersion and ability to hear others from the headset supported learning. VR and AR helped these players to better grasp the situations and take strong responsibility as social entrepreneurs. The general understanding of social enterprise related tasks was good. In module 5 the strategies were discussed and proactive attitudes taken only if the game rules and motor motion were understood well. Written instructions in module 5 supported the learning process as well as the video shown beforehand.

In prototype 2 the participants lacked time to focus deeply on engaging with the prototypes, understanding the game rules. Several learners could not handle the controllers and the situations technically quick enough and did not grasp what they could do in the activities. The games would have needed better immediate decision-making feedback to see the results of dynamic actions. The participants had difficulties in connecting theoretical knowledge with the dynamic decision-making actions. Nausea was often felt in the last part of the activity, also learners experienced fatigue and frustration. In Module 3 the technological setup was too complex, teams and Edison platform combination was not intuitive, and technology hindered the collaborative activity. In module 5 the game rules were perceived as overly complex.

The prototype 3 was very didactic, taking the learners through steps. More experienced participants were faster, but everyone could potentially understand the tasks. In prototype 3 those who were able to complete the activities found them enjoyable. Some users with prior knowledge of the subject, especially teachers, were able to recognize the potential usefulness of the VR module or lesson, especially if it were adapted to specific teaching content. Some users identified the potential of the VR simulation module to represent physical phenomena, offering an interactive environment where they could explore different configurations and better assimilate the educational content. A sandbox type experience where the most interested participants can feel comfortable with the technology would enhance spending additional time with situated VR experimenting.

In prototype 3 the VR motor skills were to be learnt first, the lack of these hindered interaction with the prototype. Many participants did not learn these motor skills during the pilot at sufficient level to proceed well. Despite the guidance texts in VR, learners did not read them and needed additional guidance from human supporters. It was difficult to grasp learning objectives only from the VR headset information. Vast majority of users experienced nausea and dizziness, motion sickness especially in flying, some felt disoriented and did not remember learning objectives. The knowledge of motor skills in earlier modules were not transferred to the next modules. Learners had issues in pumping to the cables when being in

VR headset and needed a supporter to guide them from dangers in the room. Some learners felt reluctant to complete tasks in free exploration and finished quickly.

The perceived sustainability of the prototypes differed and depended on the local infrastructure and digital readiness. For example, prototype 1 was considered potentially technically sustainable, but would require VR infrastructure, servers, VR equipment and better integration with Moodle platform to be used in larger educational settings across different faculties. Also additional training would be needed to scale up the approach. In one university it was considered too simple contentwise. Prototype 2 was considered to be too equipment intensive for large scale usage. The gamified scenarios, the contents of AI chatbots with video were considered useful with future learning purposes. The translation was needed to apply it in national settings. The usefulness of the situated learning social entrepreneurship were seen in the future situations. The universities with limited technical availability would require infrastructural and technical updates to use this prototype. Prototype 3 was considered challenging in the current form, because it required additional guidance and it would need larger user autonomy. It was not easily connectable with specific learning situations. Prototype also was causing motion sickness and cognitive load that was considered an obstacle in learning situations. The VR infrastructures at the universities should be enhanced to use the prototype with a larger number of students.

Annex 1

Table 3. The overview of testing and piloting of e-DIPLOMA prototypes

Piloting method	Sample	Methodology	References to the results
The usability testing phase			
The usability testing phase of e-DIPLOMA prototypes	Involved a small sample of a total of **10 participants,** 5 men and 5 women, from 21 to 45 years.	In the usability testing period all 3 prototype's all modules were tested. The SUS scores and qualitative data were collected through the Thinking Aloud methodology and questionnaires (for more details see D.5.3) from this piloting sample.	D.5.3 provides an overview of usability testing in three prototypes.
e-DIPLOMA piloting phase The piloting was done in two groups: experimental and control group. The control group consisted of participants who will not use the disruptive technologies incorporated into the three learning prototypes. Instead, they will follow traditional learning methods or use standard educational tools commonly employed in the current educational setting. The experimental group consists of participants who will use the three prototypes to incorporate disruptive technologies for learning. This group is designed to test the effectiveness of these technologies in enhancing learning outcomes.			
Monitoring the piloting process	**422 learners** participated in the piloting of three e-DIPLOMA prototypes, as is indicated in Table 2 (D.3.5.). We reached lower numbers of participants **(77-96%)** than expected in the grant proposal 450 (see D. 3.5. Table 2).	The Piloting process was traced by **the qualitative observation survey** led by WP3.	D.3.5 provides an overview of monitoring the piloting process D.3.1 presents the guidelines that were synthesized from this qualitative data collection process on the theoretical and empirical bases.
The analysis of best practices when learning with disruptive technologies	**985 unique lesson experiences** where knowledge gain could be related with the e-DIPLOMA prototype design elements.	The **cognitive complexity analysis** of the e-DIPLOMA learning modules content (See D.2.1, section 3) **Pre-experimentation and post-experimentation evaluation of knowledge** (See D.5.2) was associated with the learning design cognitive complexity	D.2.1, section 3 analyzed the e-DIPLOMA prototypes' learning design elements. D.2.1, section 4 analyzed the data from the pre-experimental knowledge and post evaluation knowledge exam. For knowledge testing the data from experimental settings only were used. These data were related with the best practices in disruptive learning designs of e-DIPLOMA prototype elements (see D.2.1).

The analysis of the learners psychophysiological impacts	The **psychophysiological data were collected from 404 learners** from control and experimental groups (see Table 3 in D.5.4). After filtering the data, 89% of the original observations were retained (see D.5.4, Table 4). The retention rate by prototype was: 96.1% in Prototype 1, 95.3% in Prototype 2, and 75.8% in Prototype 3. D.5.4, tables 5,6,7 introduce the overview of the unique learning metrics measurements that were used for the hypothesis testing. **Approximately 250-918 unique psychophysiological data measurements could be taken** in the experimental setting with each instrument, and in the control group similar numbers could be reached (Tables 5,6,7 of D.5.4.) .	During the pilot the learner data were collected with various approaches (see D.5.2.) The experimental protocol (procedure) contained: **1. Informed consent; 2. Establishment of the baseline a. Cognitive skill questionnaires, b. Psychophysiological baseline, c. Cognitive tasks, d. Pre-experimentation knowledge, e. Evaluation of emotional state; 3. Realisation of the learning experience (XR); 4. Post evaluation a. knowledge exam, b. Evaluation of the emotional state, c. Usability Questionnaire (at the end of each prototype).**	D.5.4, section 7 The analysis of the learners psychophysiological data is presented in D.5.4 section 7 Validation study.
The analysis of ethical aspects' and social impacts	**428 participants took part in an ethical and social impacts survey.**	**The ethical aspects' and social impacts pre- and post survey** were attributed to the learners (see D. 5.5).The survey was attributed before each prototype and at the end of the last module in the prototype.	The survey results are presented in D.5.5. Section 6.

Table 4. Changes in the e-DIPLOMA prototypes

Prototype, module	Problems	Fixes	Re-test evidence (Date/Institution)
P1M1	Identified that certain knowledge areas were not sufficiently clear in the initial explanations.	Two additional videos were produced to better introduce the topics and ensure the correct execution of subsequent modules.	January 2025 / UJI
P1M2	Issues were identified in the interaction with the blocks.	Resolved by refining the interaction mechanisms and adjusting how the blocks interact with each other.	February 2025 / UJI

	Usability issues related to deleting blocks using Virtual Reality controllers were identified.	Resolved by introducing explicit visual tools to facilitate block removal.	January 2025 / UJI
	It was observed that users overused the online help feature to progress through the exercises.	A waiting period between consecutive accesses was introduced to encourage more autonomous problem-solving.	February v2025 / UJI
	It was identified that the game could only be played in a strictly sequential manner.	Addressed by enabling direct access to individual levels.	March 2025 / UJI
P1M3	No issues detected.		–
P1M4	Performance issues were found with tablet AR.	Minimum system specs were raised.	February 2025 / UJI
	Issues were encountered in the detection of physical objects due to variable lighting conditions in the environment.	Addressed by expanding the variability range of the image detection parameters.	March - April 2025 / UJI
	Users had difficulties operating the module, as the instructions were provided only in text form and were often not followed.	An in-application guided tutorial was implemented to visually demonstrate the required steps and improve usability.	March - April 2025 / UJI
	Issues were identified in the calculation of correct responses after introducing multilingual support.	Resolved by managing the language configuration exclusively at the beginning of the practice session.	March - April 2025 / UJI
P1M5	Multiple concurrent sessions could cause errors.	Dynamic connections to multiple servers implemented.	May 2025 / UJI
	Challenges were encountered when attempting to start the server.	Addressed by developing and integrating a launcher directly into the platform environment.	May 2025 / UJI
	Issues related to connectivity with the	Resolved by enabling the possibility of running the server across different	May 2025 / UJI

	server.	regions, allowing access from its own IP address.	
	Issues were identified in the interaction with the blocks.	Resolved by refining the interaction mechanisms and adjusting how the blocks interact with each other.	May 2025 / UJI
P2M1	The pilot schedule was inflexible.	Added option panels at activity start to customize number of participants, number of rounds, timer length (or disabled).	Sept 2025 / BME
	Poor feedback when selecting NPC markers, difficult to click.	Sound feedback when clicked. Made much easier to click, even from a distance.	Sept 2025 / BME
	NPC markers visible in the city, allowing players to teleport to another NPC.	Markers do not show up in the city.	Sept 2025 / BME
	Performance bottleneck on poor computers.	The city is made static, FPS increased.	Sept 2025 / BME
	Ending conversation was possible by spoken command, which was not perfectly reliable, and had to be explained to participants.	New intuitive UI elements have been added.	Sept 2025 / BME
	While waiting for an AI response, the "thought cloud" that appeared was not clear to all users.	Changed to animated spinner.	Sept 2025 / BME
	Some students did not catch all of the NPC's answers.	In addition to text-to-speech audio, the text is also displayed in a panel.	Sept 2025 / BME
	Feedback indicating the discovery of a new character was limited.	Now a panel with name and image pops up.	Sept 2025 / BME
	The first question was always to prompt the NPC to introduce themselves and their business. This triggered AI use, which is a cost factor.	NPCs automatically introduce themselves using pre-generated text.	Sept 2025 / BME
	Headset calibration	This can no longer happen.	Sept 2025 / BME

	mistakes could cause the player to appear outside of the starting room.		
	Existing environmental keys (variations in city architecture) were too subtle to notice.	NPC's were given unique animated character models and environments with strong clues about their roles.	Sept 2025 / BME
P2M2	The pilot timeframe was insufficient to learn and master the game.	The game's timeframe has been extended. Multiple sessions (with a break) are now recommended.	Oct 2025 / BME
	The game was too challenging.	Some parameters have been tweaked to make it easier to maintain the city population.	Oct 2025 / BME
P2M3	The combined use of remote desktop access, video conferencing, AI tools, and the Edison platform created technical complexity for most participants, limiting effective engagement.	Adopt Edison OnCloud as a streamlined alternative to simplify access and reduce technical complexity.	May 2025/ BRA
	The limited pilot duration restricted participants' ability to fully understand and benefit from the activities.	Extend the pilot duration to a longer, full-length activity timeframe to allow deeper engagement and more effective learning.	May 2025/ BRA
P2M4	Feedback about the operation of the enterprise was in the form of task progress indicators, not helping to understand the structure.	A 2D animation area has been added, where all employees can be seen to perform their tasks, and item stocks can be monitored. has been added.	Oct 2025 / BME
	The user interface for assigning tasks was unappealing.	Colorful icons with tooltips were added, with strong outlines to indicate selected items, and a clock overlay to show progress.	Oct 2025 / BME

	The UI was overcrowded.	Job interview and team management phases have been separated into distinct screens.	Oct 2025 / BME
	The piloting schedule was too rigid.	Milestone targets have been added to replace the timer.	Oct 2025 / BME
	Student performance feedback was a numerical income value, which was not beginner-friendly.	Target milestones have been added to guide the student from simple goals to forming a performant team.	Oct 2025 / BME
	It was difficult to see the discovered values and traits of employees/applicants.	There is a new panel with the employee portrait, values, traits, and the negotiated salary.	Oct 2025 / BME
	Conflicting values in the team were only represented by employee comments, which was challenging to track.	A relationship panel with a colored graph of conflicting/compatible values.	Oct 2025 / BME
P2M5	It was difficult to learn the game in the allotted time.	A walkthrough video was created. It is now recommended to play the game multiple times.	Oct 2025 / BME
	There were no visual cues to indicate which cards could be played where (a key element of learning in the game).	Visual highlighting of the relevant areas has been added while dragging cards.	Oct 2025 / BME
	There were minor visual glitches with text and board rendering.	These were fixed.	Oct 2025 / BME
	It was unclear when a card or other game element should be clicked or dragged.	The mouse cursor now changes according to the possible action corresponding to the pointed element.	Oct 2025 / BME
	Camera movement was instantaneous, not providing cues on which part of the board is shown.	Camera movement is now always smooth and followable.	Oct 2025 / BME
	Promotion cards had to be dropped on citizen pawns, and not on city	Now there is a multi-layered drop target system, which means cards can be dropped on areas, or on	Oct 2025 / BME

	segments, which was frustrating. Similarly, when dropping a card on an area, accidentally dropping on an element already in the area made the action to fail.	elements already in the areas, and they will still be correctly placed.	
	Market research and market segmentation capabilities on the same social statistic could be selected twice, which was not a useful option for the players.	Now already acquired capabilities do not accept further cards.	Oct 2025 / BME
P3M1	Some users had difficulty using the controller/clicking UI elements despite clear instructions.	New UI design with richer set of controls. Standard UI look for all modules and reused UI as much as possible between models to avoid re-learning behavior.	July 2025 / TUD
P3M2	UI did not accommodate different text length due to localizations (translations).	New UI tooling that resizes to match text.	July 2025 / TUD
P3M3	Slightly inconsistent line art style.	"e-DIPLOMA style" line art rendering developed and used for the entire prototype.	Mar-July 2025 / TUD
	Navigation methods could be enhanced.	Holonomy navigation demonstrator developed. The navigation methods were refined for better controllability and reduced cybersickness.	Oct-Dec 2024 and July 2025 / TUD
P3M4	Input methods not explored.	Swipe keyboard in VR added.	July 2025 / TUD
	More applications could be presented.	Music theory training demonstrator and piano training demonstrator developed.	September 2025 / TUD
P3M5	The interpersonal distance calibration module lacked realism.	More realistic face model with facial expressions developed.	July 2025 / TUD

e-DIPLOMA

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