This document describes the final evaluations of the experiment PLAYHIST. It outlines the experiment process, the technological problems and final decisions, presents and analyses the results and discusses the experiment outcomes.
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<td><strong>Workpackage 4.14</strong></td>
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<td><strong>Deliverable lead organisation</strong></td>
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<td>Pablo Aguirrezabal, Rosa Peral, Ainhoa Pérez, Sara Sillaurren</td>
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<td>Magnus Eriksson (Interactive), Stephen C. Phillips (IT Innovation)</td>
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<td><strong>Status</strong></td>
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<tr>
<td><strong>Due date</strong></td>
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1. Executive Summary

This deliverable presents the final results of the PLAYHIST experiment at FHW. As stated in previous deliverables, the PLAYHIST experiment aimed to create a more engaging experience for the FHW visitors transforming one of the interactive projections into a multiuser game in which the participants had to achieve a specific goal moving and interacting in the virtual world looking for a learning experience about Hellenic history. In this document, the experiment preparation is described including the integration between PLAYHIST software and EXPERIMEDIA modules. The final architecture is also outlined and so are the different metrics for VIA assessment.

The second section deals with the experiment execution. Two experimental sessions were conducted in the FHW with visitors, and two more have been conducted with Tecnalia volunteers, which also were used for final testing of the system.

The Experiment Results Analysis section comprises the analysis of the different metrics collected during the experiment runs. The information gathered directly from EXPERIMEDIA modules like ECC or by means of questionnaires has been evaluated in order to identify the degree of compliance of the initial hypothesis of PLAYHIST experiment.

Finally, the dissemination efforts carried out by Tecnalia are described, and conclusions are extracted for the overall experiment process.
2. Introduction

This document describes the results of the experiment PLAYHIST. It describes the final status of PLAYHIST game, the integration with the EXPERIMEDIA baseline components and the conclusions and recommendations not only for the game but for all the elements involved in the experiment. It also outlines the differences and improvements regarding the "D4.14.2 PLAYHIST Experiment Progress Report" content.

2.1. Experiment Objectives

The objective of the PLAYHIST experiment is to assess the effects of using gamification in Quality of Learning (QoL) and QoE. The hypothesis that will be tested is that learning by playing provides a better understanding of an historical subject.

Additionally, the experimenters' aim in carrying out the experiment was to investigate the following issues:

- The feasibility of using games to communicate historical information along with the improvement on the Quality of Learning (QoL) for the visitors of a history museum as FHW. The analysis of the QoL could provide the feasibility of using a gaming model to improve the learning experience of the FHW visitors.
- The feasibility of connecting the EXPERIMEDIA modules with Unity3D engine including the avatar creation and real time animation modules. ECC and 3DCC could be used for future game and interactive application development with new and rich functionalities.
- The feasibility of cluster rendering with Unity3D in a cutting edge facility as the Tholos. This was the most difficult of the objectives as a lot of programming was involved.

2.2. Experiment Benefits

PLAYHIST experiment aims to get numerous benefits for different stakeholders:

1) For visitors: Improvement of the overall experience of the audience through their interaction with a serious game, in two facets: engagement and learning. This is particularly interesting when used for historical content dissemination.

2) For the venue:
   a) Improvement of the capacity to attract more visitors and offer better experience by providing a new additional service to the ones currently available to their visitors. People could choose between attending the interactive film session or playing the game with the same objective: getting historical knowledge about ancient Greek.
   b) Reuse in a new way of 3D content already developed. FHW could take advantage of all the 3D content created for their productions, and develop new services and applications for dissemination.
   c) New better way to capture visitors' interaction and statistical data. PLAYHIST game registers in real time, using a Unity3D plugin specifically developed for the experiment, all the interactions and results achieved by the player through the ECC.
module of EXPERIMEDIA. The analysis of this information in future games could allow the FHW personnel to identify areas of improvement for their productions.

3) For FMI: a technique/method to live streaming 3D avatar models and their movements inside an immersive dome-shaped Virtual Reality "Theatre" (Tholos).
3. Experiment Preparation

3.1. Venue and Participants

The PLAYHIST experiment has taken place in the Tholos, inside the Hellenic Cosmos Cultural Centre, with two previous runs in Tecnalia installations in Spain.

At the beginning of the project, two different possibilities were considered for the projection of the game:

- One of them was projecting on a unique projector in the centre of the Tholos with a unique laptop and projector.
- The other one was using a machine with three graphic outputs to be connected to the different projectors.

Finally, the second solution (more complex) was chosen and developed.
The voluntary participants have been recruited by FHW staff, following the indications of Tecnalia, about not being children and people with medium degree. The final participants were recruited among the visitors to the Hellenic Cosmos.

3.2. Game Features

3.2.1. Game progression

The main steps for the game progression will be:

- The visitors were given the opportunity to personalize the 3D avatar (in a laptop, before entering the Tholos). These participants had to take a picture of them and through the application get their own character with their face. The rest of the game participants will be associated with a standard avatar.

ATTENTION!

- The Agora is not suitable for a female avatar. A respectable woman would not be seen walking alone in the city, unless escorted by her husband, mother, slave...
- We had to go over this problem including a warning message for this issue.

- The visitors were presented the main objective of the game, a brief historical introduction to the game and the steps or mini-games to get the final objective.
- For each mini-game, there was an initial brief presentation of the specific challenge, and immediately, the visitors began to play the mini-game. The end of each mini-game was defined both by time ending assigned to each mini-game or by all the visitors finishing and reaching the objective, the first of both events. Depending on the level of achievement on each mini-game, the visitor were assigned punctuation and ranked in a general list (visible on the general screen of Tholos for all the visitors).
- Once all the visitors have passed through all the mini-games, there was one winner.

Here we have a screen capture of the avatar creation process:

Figure 2: PLAYHIST Tablet Game - Screenshot 1
### 3.2.2. Game mechanics

The game mechanics is explained in the following table, one row per mini-game developed:

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Description of game mechanics</th>
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<tbody>
<tr>
<td>Load a boat with the goods to be sold</td>
<td>Each player is in their boat, and some goods are coming, so they have to choose which ones to load in their boat. The challenging concept is a time limit. Goods are arriving to the ship and the player has to sort them before the next good comes. As the game progresses the arriving of the goods goes faster and faster. The player would have to choose strategy between taking the time to sort goods properly, or throwing them into the boat fast enough to be able to get back and take the next goods coming. If the player is not fast enough back for the next good, it will fall down and break. More goods stacked during the limited time of the game give more goods to sell in the next game.</td>
</tr>
<tr>
<td>Trade with the dealers in the Agora in order to get the most benefits for the goods brought to Miletus</td>
<td>This game is structured as a dialogue-based negotiation/haggle game where the player has to reach a deal with the buyer. The buyer and the participant will have to reach an agreement to fix the price for the goods. Based on the information about approximate prices of goods given in the mini-game help, the participant has to decide one price offer for the buyer. After that, the buyer will offer a new price for the participant's good. The limits for the game are, participants will have three chances to reach a final price or the time limit which is three minutes.</td>
</tr>
<tr>
<td>To buy a votive stele with the silver or gold obtained and present it in the Annual festivities in honour of Apollo</td>
<td>This challenge will be structured on the basis of solving a jigsaw puzzle. Once the participant has finished the Agora mini-game, he/she will have enough money to buy a votive stele, which in the process falls to the ground and breaks. This will lead to the player to a challenge type jigsaw puzzle to reconstruct the votive stele and allow him/her to dedicate it to the god in the Sacred Way.</td>
</tr>
</tbody>
</table>

Here we have some screen captures from the tablet PLAYHIST game:
Figure 3: PLAYHIST Tablet Game - Screenshot 1

Figure 4: PLAYHIST Tablet Game - Screenshot 2
Figure 5: PLAYHIST Tablet Game - Screenshot 3
3.2.3. Architecture

The following diagram depicts the different components involved in the experiment:

![Diagram of PLAYHIST experiment Architecture](image)

Figure 6: PLAYHIST experiment Architecture

Different components/modules have been developed:

- **PLAYHIST Main Game Instance**: This component is the Unity3D 3d game which will be projected in the Tholos. It includes:
  - 3D assets: all the 3d assets composing the Miletus 3D scene, including buildings, avatars, the terrain, etc.
  - ECC C# client: the plugin containing all the functions and methods to take part in an EXPERIMEDIA experiment and report metrics, including pull and push modes, and dynamic Entities creation.
  - 3DCC motion capture client: we have also included inside this Unity3D development the 3DCC motion capture client in order to receive the movements from the 3DCC motion capture server application.
  - 3DCC avatar sync development: we have developed and integrated a simple method in order download corresponding avatar to each player from 3DCC Avatar Repository.
  - Network server component: This main instance includes also all the network features to create a real-time synced multiplayer game, following a client-server paradigm.
**PLAYHIST Tablet Instance:** This component is the Unity3D tablet game, which will be directly controlled by the FHW visitors. It includes:

- The 2D user interface: with explanations about history, game mechanics, instructions, etc.
- The three 3D mini-games: including the second one which allows visitors to directly interact with their players watching the Tholos.
- Network client component: the client part for each tablet inside the client-server paradigm.
- The metrics report module, to send metrics to the main instance, which centralize the shipment to the ECC.

**PLAYHIST Expert Instance:** this is a variant of the Main Game Instance, a light version without the ECC and 3DCC functions. It just allows the Expert inside the experiment to see the players' interactions and movements as if he were watching the Tholos but from remote location (at home, at the office, in other country...)

The connections between these Experiment components/modules, and the EXPERIMEDIA components are:

- **PLAYHIST Main Game Instance** is directly connected with the ECC service and the two modules of the 3DCC component.
- **PLAYHIST Tablet Instances** are connected to the Main Game Instance
- **PLAYHIST Expert Instance** is also connected to the Main Game Instance

As can be seen all management is centralized in the PLAYHIST Main Game Instance

This client-server architecture implies the development of different parts of the multiplayer game for being displayed synced in different screens, as the following flowchart shows.
3.2.4. 3D Scenery

The PLAYHIST game progress is based in three different scenarios: the harbour, the Agora and the Sacred Way. In these screen captures can be appreciated the details:

---

Figure 7: PLAYHIST experiment Flowchart

**PLAYHIST Start**
- Telephone selection
- Telephone selection

**Historical Introduction**
- 2022

**Game Progress**
- Goods sale game introduction
- Goods sale game introduction
- Time finished

**Agora Scene**
- Player scene

**State building game**
- Goods sale game introduction
- Time finished

**PLAYHIST End**
- Quiz Game

---

[Diagram showing the flowchart of the PLAYHIST experiment with three scenarios: Harbour, Agora, Sacred Way.]
Figure 8: PLAYHIST Tholos Projection - Screenshot 1

Figure 9: PLAYHIST Tholos Projection - Screenshot 2
The original 3D scenarios from provided from FHW have been modified and adapted in order to fulfil the game and experiment requirements.

### 3.3. Integration with EXPERIMEDIA Baseline Components

#### 3.3.1. ECC

To integrate with the ECC component all the effort has been focused in the development a C# based Unity3D plugin. This plugin allows any Unity3D development, to report to ECC with the following capabilities:

- Connect as a client to an running experiment
- Create Entities in runtime (dynamically)
- Create push metrics in runtime (dynamically)
- Create pull metrics in runtime (dynamically)
- Disconnect as a client from running experiment.

PLAYHIST experiment, as mentioned inside 3.2.2 point, reports to the ECC as a centralized unique client from the PLAYHIST Main Game Instance. The PLAYHIST Main Game Instance itself is an entity, and then a new entity is created on demand for each player who takes part in the multiplayer game.

#### 3.3.2. 3DCC

To integrate with the 3DCC we have developed a method to "consume" the avatars from the 3DCC avatar repository, which basically consists on download a texture and apply it to a model in runtime. Furthermore, to include the motion capture module, we have imported a Unity3D prepared package developed by CERTH inside our Unity3d development. Once it is included we have just configured it to act like a client and listen the 3DCC motion capture client, which captures Expert movement with a Kinect. All the data is managed by RabbitMQ (not related to the ECC instance).
3.4. VIA Assessment

3.4.1. QoE Metrics

The Quality of Experience has been measured through Lime Survey (defined a questionnaire, in Appendix A) and directly from the game through ECC. It has been only been measured for participants who played the game.

The quantitative metrics (measured by the ECC) are the following:

- Language selected
- Time to click OK button (in an information screen)
- Number of goods collected in a fixed time
- Number of times help screen is displayed
- Number of stand changes (Agora mini-game)
- Number of expert help required (Agora mini-game)
- Does the player follow the expert recommendations?
- Time to solve each mini game
- Number of iterations for each deal in the Agora mini-game
- Number of movements to complete the votive stele
- Number of mini-games completed

The qualitative metrics (measured by the Lime Survey) are the following (for the control group of the experiment):

- The educational potential of the game (General)
- The level of entertainment (General)
- Sensation using a tablet for playing the game (General)
- Difficulty in finding his/her character in the global scene (General)
- The most liked mini-game (General)
- Used own’ s face to create the avatar or not (General)
- Following the expert indications or not (General)
- Avatar creation process difficulty (Avatar Creation)
- Happiness with the chosen avatar (Avatar Creation)
- Expert participation Help (Expert Participation)
- Mini-game 1 (unloading the ship) opinion about length, easiness, enjoyment, use and creativity
- Mini-game 2 (selling the goods) opinion about length, easiness, enjoyment, use and creativity
- Mini-game 3 (building the stelae) opinion about length, easiness, enjoyment, use and creativity

3.4.2. QoS Metrics

The Quality of Service metrics considered in PLAYHIST experiment are:
• Frame rendered per second (FPS)
• Players Round-Trip delay Time (RTT)

Additionally it has been done a network latency study with 3DCC avatar motion capture module (10 people study).

3.4.3. QoL Metrics
The Quality of Learning has been measured through a questionnaire (Kahoot Quiz in Appendix B) presented to both control groups, the one in the interactive film and the one playing the game. The metrics were:

• Location in time of the visited city of Miletus
• Meaning of votive stela
• Name of the main harbour of Miletus (the one in the first mini-game)
• Good NOT sold in the Agora
• Basic unit of Athenian currency
• Use of purple dye
• Name of the main building in the Sacred Way

These types of metrics were chosen based on the three sceneries elected for the game-flow and the learning objectives defined in the first part of the experiment. In fact, the interactive film provided information in the visit (which at some points is broader than the mini-games one) had to be modified in order to include the same information given in the gameplay. At the end, the same questionnaire was presented to both control groups (the one seeing the interactive film and the one playing the game), so the Quality of Learning could be correctly inferred.

The Quality of Learning questions were designed so that all the information provided at different steps of the game can be checked, but there were not specific question to detect if with some of the mini-games the participant had learnt more than with other (due to the questionnaire had to be the same as the one for the participants in the interactive film).

3.5. Ethics & Privacy
The experiment has been conducted in accordance with EXPERIMEDIA’s ethical and data protection procedures and will follow the measures defined by the EXPERIMEDIA’s Ethical Issues Coordinator and Data Protection Coordinator. In this sense, the design and execution of the experiment will respect the ethical principles and guidelines -defined in the EXPERIMEDIA deliverables "D5.1.1 EAB and DPB Operating Procedures" and "D5.1.2 Ethical and regulatory framework for social and networked media".

During the experiment runs held in the FHW in Athens, the following personal data has been registered:

• Name and personal identification number
• Participant image for avatar creation (not related to name or personal number)
Before starting the experiment, all participants signed a consent form (9.Appendix C Consent Form) with personal data purpose explanation.

The processing of personal data comprises the following actions:

1) Spanish DPA was notified before the experiment runs and personal data file was registered as medium level type.
2) Consent form signed kept until experiment assessment finishes.
3) Participants' image for avatar creation is not finally kept in the tablets but in the Avatar creation server. It will also be erased after experiment assessment.
4. Experiment Execution

4.1. Time Plan

The following time plan shows the final schedule of the experiment. No major changes have occurred apart from the experiment runs in the FHW that had to be done in September instead of July or August due to agenda problems.

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Figure 11: PLAYHIST experiment time plan

4.2. Internal Runs

In Tecnalia (Spain) there have been two runs previous to the definitive one in the Hellenic Cosmos to analyse the game mechanic.

4.2.1. Setup

The first round was at the end of July, and the second one at medium August. The participants were voluntary employees from Tecnalia. They were from different departments and with distinct technological skills.

4.2.2. Execution

At execution time in the first run, some issues were detected, for example:

- Accessibility/usability issues, in the sense people didn't see very well the box dedicated to fulfil the nickname.
- Games difficulties. In the first mini-game (the one for the boat cargo) participants didn't know how to drive the goods to the correspondent box. It was very difficult for them because the container box were located on both sides on the screen. At last, we decided
to locate the boxes on the bottom part of the screen and slow the speed of the falling goods, so the participants could find the game more pleasant.

- People complained there was too much text to read before beginning each game.

In the second run of August, most of the first round’s issues were corrected. Tecnalia had not much to do respecting to the length of the text as it is necessary to understand the game and the History to be learnt, for the purpose of the experiment. In general, the experiment process was much more fluid the experiment, the participant could complete the game almost without help.

And summarizing, the participants enjoyed and learnt playing the PLAYHIST game.

4.3. FHW Runs
It has been a unique run on the 2nd September. People from Tecnalia were on Hellenic Cosmos on 1st September in order to fix all the equipment and configure the architecture.

4.3.1. Setup
The participant recruitment has been done by FHW. There were four groups (two for the interactive film and two for the game) of four people each. Most of the people were Greek, and directly recruited by FHW among their contacts (12 people). The rest (4 people) were tourist visiting the Hellenic Cosmos, recruited directly there.

4.3.2. Execution
There were three rounds in the final execution:

- First round: 4 Greek people playing the PLAYHIST game. After finishing the game, they completed both questionnaires in Lime Survey (QoE) and Kahoot (QoL)
• Second round: 8 people, divided in two groups, 4 Greek people and 4 museum visitors. Both groups saw the video together because of the lack of time, due to the quantity of shows in the Tholos that day. After seeing the interactive film, they completed the Kahoot questionnaire (QoL), so the results can be compared with the other groups.

• Third round: 4 Greek people playing the PLAYHIST game. After finishing the game, they completed both questionnaires in Lime Survey (QoE) and Kahoot (QoL)

The mechanics for the experiment is the following:

• The visitors configure their character in the game, previously to enter the Tholos. They had to choose between a standard character and a personalized one. If they decided to personalize the character, they were taken a picture of their face and through the application get their own character with their face.

• The visitors entered the Tholos with the tablets and were presented the main objective of the game, a brief historical introduction to the game and the steps or mini-games to get the final objective.

• For each mini-game, there is an initial brief presentation of the specific challenge, and immediately, the visitors began to play the mini-game. The end of each mini-game was defined both by time ending assigned to each mini-game or by all the visitors finishing and reaching the objective, the first of both events. Depending on the level of achievement on each mini-game, the visitor were assigned punctuation and ranked in a general list (visible on the general screen of Tholos for all the visitors).

• Once all the visitors passed through all the mini-games, they were asked to fulfill two questionnaires, one for measuring the QoE through the Lime Survey and the other for measuring the QoL, through the Kahoot tool.
Some images of PLAYHIST experiment in the Hellenic Cosmos:

Figure 13: PLAYHIST game projected in the dome-shaped Virtual Reality "Theatre" - Tholos

Figure 14: Experimenter playing with the tablets inside the Tholos
5. Experiment Results Analysis

The quantitative metrics (measured by the ECC) results can be observed in these graphics:

Figure 15: QoE - Finished games

Figure 16: QoE - Number of movements - mini-game 3
Figure 17: QoE - Number of goods collected - mini-game 1
Figure 18: QoE - Second to click OK button
Analysis of ECC metrics:

- It can be appreciated that, although Game1 and Game2 were finished by most of the participants, no participant could finish Game3. This is a curious data, because the mechanics of third game (jigsaw puzzle) is the most common of the three developed games. Referred to this third game is also analysed the number of movements made in the game progress. Half of the participants made a big number of movements, although without completing the game.

- About the time to click the OK button in the different screens, it is observed that the screens presenting the game mechanics and the objective of the game have been read more carefully than the rest of the screens. This is a good point to understand correctly the game mechanics.

- About the Help screens in the different games, it is observed that the first games Help screen are seeing more time than the final game screen. This metrics can mean the participants are more and more inside the game mechanics.

The qualitative metrics (measured by the Lime Survey) results can be observed in the following graphics:
Figure 20: QoE - Experiment Educational Potential

Figure 21: QoE - Experiment Level of entertainment

Figure 22: QoE - Tablet usage
Figure 23: QoE - Mini-game preferred

Figure 24: QoE - Avatar Creation Process
Figure 25: QoE - Expert Participation

Analysis of Lime Survey metrics:

- Asked the participants about the educational potential, they think is similar for adults and teenagers, but less for children (maybe it can be due to the advanced explanations about the History made in the different mini-games).
- About the level of entertainment the conclusion is that the best will be for teenagers, but followed not very far by adults and children, at the same score.
- Using tablets for playing the game is seen by most of participants like an added value for the experiment (with half of the participants with the highest score)
- The mini-game people liked most was the final puzzle about the votive stelae, followed by the selling of goods in the Agora, this indicates an "in crescendo tempo" in the game progress. Although curiously the votive stelae mini-game was not completed by any participant, it resulted in the most enjoyable. This fact can be due to the own difficulty of the game. In the real life is also very difficult to complete a game of this type if you are not familiarized with the jigsaw movements.
- Most of the participants find quite useful and with good final result the process of avatar creation. About the easiness and quality there are very different results, and no conclusion can be derived from this data.
- About the expert participation, half of the participants found it useful, and the difficulty of creating the avatar is medium in all the participants.
- The globally better rated games where the selling of goods and building of votive stelae, with a top punctuation for the creativity of selling goods. This issue seems to be a good mechanism for learning the goods sold, the currency and the system of negotiation.
- Participants have felt the Lime Survey questionnaire was tedious and very long.

5.1. QoS Analysis

The Quality of Service was measured with the ECC. We directly measured two metrics:
Frames per second of the PLAYHIST Main Game Instance projected in the Tholos. The result is 22.90 fps on average during the experiment. It is not a great result, by no participant notified reported a bad graphic sensation with the Tholos projection.

Players' Round-Trip delay Time: delay time between tablets and Main Game Instance network communications. It was measured for each tablet. The result was very good with a 13.8 ms on average. There weren't any network problems.

Indirectly the experiment measured also 3DCC avatar motion capture QoS metrics related to the expert with the Kinect: Skeleton Confidence, Skeleton Jerkiness X, Skeleton Jerkiness Y, Skeleton Jerkiness Z and Skeleton Quality. The results were normal and have no influence in the experiment because of the Expert role inside the game (just move to get attention).

Apart from ECC objective metrics, we performed and study to measure the users' assessment in bad network conditions. In this case, how bad network conditions affect the expert remote motion capture.

To simulate network conditions we have used an open source Knoppix based virtual machine named WANem (http://wanem.sourceforge.net/), which is basically a Wide Area Network Emulator.

We have configured this machine to be in the same network that the expert of the experiment, and the machine which is running the game.

![Network simulation architecture](image)

**Figure 26: Network simulation architecture**

To force the real machines to pass through the WANem virtual machine, it has to be configured on each real machine like this:

Type this in a command line of the PLAYHIST Game machine:

```
route add 172.28.2.97 mask 255.255.255.255 172.28.2.200
```

Type this in a command line of the Expert machine:

```
route add 172.28.2.88 mask 255.255.255.255 172.28.2.200
```
This is all that is necessary to configure the environment. Once you have this WANem allows you to change network parameters (RTT included of course) through a web interface.

The subjective results of ten people study are:

<table>
<thead>
<tr>
<th>Delay (ms)</th>
<th>User 1</th>
<th>User 2</th>
<th>User 3</th>
<th>User 4</th>
<th>User 5</th>
<th>User 6</th>
<th>User 7</th>
<th>User 8</th>
<th>User 9</th>
<th>User 10</th>
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<td>2</td>
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<td>0</td>
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</tr>
</tbody>
</table>

Figure 27: Users data

<table>
<thead>
<tr>
<th>Delay (ms)</th>
<th>Users assessment (0 – 10) – Average</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>10</td>
<td>Perfect answer. Lag not noticeable.</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>Perfect answer. Lag not noticeable.</td>
</tr>
<tr>
<td>200</td>
<td>9,8</td>
<td>Perfect answer. Lag not noticeable.</td>
</tr>
<tr>
<td>300</td>
<td>5,6</td>
<td>You start to notice the lag. It has little impact.</td>
</tr>
<tr>
<td>400</td>
<td>1,8</td>
<td>The lag is remarkable. Bad sensation.</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
<td>Unable to do anything.</td>
</tr>
</tbody>
</table>

Figure 28: Study summary

5.2. **QoL Analysis**

The Quality of Learning was measured with a questionnaire defined in the Kahoot tool. The results of the correct answers made by both the participants of the interactive film and the game are in the following graphic charts:
Figure 29: Game results from Kahoot

Figure 30: Film results from Kahoot
Figure 31: QoL comparison

Analysis of Quality of Learning metrics:

- A slightly higher number of right answers in the game participants can be observed in the comparison chart and also a significantly lower portion of wrong answers. This data tells us that, at least in a first moment, participants in the game are able to remember more information about the Ancient Miletus than the ones seeing the interactive film. This data is even better having into account that game participants have spent more time since they received the historical information, due to the time spent in fulfilling the Lime Survey questionnaire.

- It can be observed a better global score obtained by people playing the game. Having into account the time in responses, this data tell us that they doubted less than interactive film participants.

- For all the participants, with no exception, Kahoot tool has been interesting and enjoyable.

5.3. Game Results Analysis

For the final and complete analysis of game results, we can mention the initial troubles with the tablet interface, so the participants could see clearly where to fulfil the information of the nickname. These problems were solved for the second run of the experiment, in the same Tecnalia installations, so for the final run at the Hellenic Cosmos, the interface was correct.

On the other side, every participant in each of the runs (both Tecnalia installation and Hellenic Cosmos) have found that Kahoot tool was very interesting and entertaining for checking the Quality of Learning.

At the same time, participants for the game run having to fulfil also the Lime Survey questionnaire, found very long and tedious completing the whole questionnaire.

5.4. Feedback from the FHW

Tecnalia’s work carried out during the experiment preparation has been recognized by Venue staff (Dimi) like the only (external) experiment that actually has used correctly the smart venue capabilities – Immersion (Tholos projection).
The use of Unity3D engine for developing the game has turn out to be a perfect solution for creating new interactive projections and games for the FHW, due to its easiness and functionalities. FHW has asked TECNALIA for the source code of the game in order to be able to learn new capabilities for their activities.
6. EXPERIMEDIA Components Assessment

6.1. ECC
Some point to summarize our usage of ECC:

- Great web based "tool" to capture and analyse data about almost any project.
- We have mainly used it to capture and record data. We haven't found a scenario to use it as a live decision-making tool.
- Used locally due to initial network conditions. Some test using it as a service for a General Assembly demo worked after a couple of changes in the original instance.

6.2. 3DCC
Some point to summarize our usage of 3DCC:

- We would have liked to use the avatar creator module web client in the experiment tablets, but due to performance problems it was only available as a service in desktop browsers.
- It would have been interesting that 3DCC avatar creator module being able to report any QoS or QoE metrics.
- 3DCC motion capture module is powerful and easy to integrate.
7. Dissemination

Tecnalia has been very active in the dissemination of the PLAYHIST experiment and EXPERIMEDIA project. All the congresses and dissemination actions are listed below:

- Laval Virtual Congress\(^1\) on April 2014 (France). Paper "Designing history learning games for Museums. An alternative approach for visitors’ engagement" accepted and a 30’ presentation in the congress by Pablo Aguirrezabal.

- A presentation entitled "Diseño de juegos históricos para el aprendizaje en museos visitas de exterior" given at 2nd 3D Cultural Heritage Documentation and Musealization Seminar (Spanish National School V-Must) on September 2014 (Madrid, Spain) by Sara Sillaurren.

- Tecnalia is organizing a workshop at the Reproductions Museum (Bilbao, Spain): “New technologies for the cultural contents dissemination” for the end of September 2014.

- The paper entitled " PLAYHIST: Jugando con la Historia. Transformación de película interactiva en juego histórico para el aprendizaje” confirmed - has been accepted in the Arqueologica 2.0\(^2\) congress for October 2014 (Ciudad Real, Spain).

- A short paper is confirmed at EUROMED congress\(^3\) that will be held on November 2014 (Lemessos, Cyprus). The presentation is entitled " PLAYHIST: PLAY AND LEARN HISTORY. Learning with a historical game vs an interactive film"

- Additionally, an article has been sent for its publication in the EuroVR association newsletter entitled " PLAYHIST: Playing with history".

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\(^2\) [http://www.arqueologiasvirtual.com/arqueo/](http://www.arqueologiasvirtual.com/arqueo/)

8. Exploitation

In the first place, the main development during the PLAYHIST experiment is the complete multiplayer PLAYHIST game. It is based on a tablet app for the users/visitors who will be players to control and interact with the second part of the game, the 3D scene, which can be projected inside the Tholos or in any plane screen. The owner of this PLAYHIST game is Tecnalia, but there will be a user licence provided to FHW, so the complete multiplayer PLAYHIST game can be used in their installations. At the same time, FHW will provide Tecnalia with visibility of the experiment and access to new possible clients using similar type of 3D theatre as Tholos.

At the same time, Tecnalia has developed during the experiment, two different plugins or modules for Unity, subject to be published to the in the Unity3D Asset Store. The provider agreement allows a wider dissemination of the results of the project and controls the revenue scheme that suits best, either free or for a fee. As other projects and developers can benefit from the results, the impact achieved will be higher and long-term. It will also be possible to extract usage statistics from the developer account tools and receive direct feedback from users around the world.

1) ECC client plugin developed for Unity graphic engine. The current functionalities include pull and push metrics and dynamic entities. This plugin allows QoS and QoE data real-time capture and record from PLAYHIST Unity3d game to measure visitors experience and service, so it could be used by any other Unity game for the same purpose.

2) 3DCC avatar creation module connection. Its functionalities are getting face textures to allow a Unity game to create 3D characters from player faces in real time.

Both plugins require the related EXPERIMEDIA modules (ECC and 3DCC) to become public access in order to be published in the asset store.

Tecnalia has also developed a Unity component for mobile devices control. This component allows visitors to use their own mobile devices to control an interactive production or game displayed in a Museum. This would avoid the installation of control devices like mice, joysticks or keyboards in the museum, minimizing usage and maintenance problems in the museum, and reducing the number of tablets for renting. This component will allow Tecnalia to offer new possibilities to our customer in the cultural market improving our business in this area. In this sense, and relate to the agreements of Tecnalia with two museums in Spain for using them as test beds of interactive technologies oriented to art and history learning (ARTIUM: Basque Museum-Centre of Contemporary Art and Artistic Reproduction Museum of Bilbao) meetings will be held to show the PLAYHIST experiment and the new possibilities for their exhibitions.
9. Conclusions

In summary, PLAYHIST experiment showed the great potential and interest that games have for historical content dissemination. They became and engaging tool and also, even text in a game, created for learning purposes, may seem too long, the Quality of Learning results obtained during the experimental runs look promising.

When considering the learning objectives of the experiment for Tecnalia, we can say that all of them have been achieved.

- The feasibility of using games to communicate historical information along with the improvement on the Quality of Learning (QoL) for the visitors of a history museum as FHW.
- The feasibility of connecting the EXPERIMEDIA modules with Unity3D engine including the avatar creation and real time animation modules. ECC and 3DCC.
- The feasibility of cluster rendering with Unity3D in a cutting edge facility as the Tholos. This was the most difficult of the objectives as a lot of programming was involved.

From the FHW technicians' point of view, the methodology and software used for creating the PLAYHIST game, open a new way of generating their productions for the Tholos, which requires at this moment a lot of effort of programming, and also, for getting new products and services like multiuser web based games.

From the visitors' point of view, a game is presented as something challenging and entertaining, so the game must fulfil these expectations. It must not be too difficult and also, usability matters must be taken into account. Responsive design must be used to get a game that can be played in any device. It has been noticeable the success of using Kahoot platform for measuring Quality of Learning.
Appendix A. Lime Survey Questionnaire

PLAYHIST

This survey is intended for collecting data about your experience during PLAYHIST experiment if you have been attending the multiplayer game.
Please fill in this survey, it will help us to know how your experience was participating in PLAYHIST experiment.

There are 12 questions in this survey.

Generales

[] Please rate the educational potential of the Ancient Miletus game: 1=Low, 5=High *
Please choose the appropriate response for each item:

For children: 1 2 3 4 5
For teenagers: 6 7 8 9 10
For adults: 11 12 13 14 15

[] Please rate the level of entertainment: 1=Low, 5=High *
Please choose the appropriate response for each item:

for children: 1 2 3 4 5
for teenagers: 6 7 8 9 10
for adults: 11 12 13 14 15

[] Did you like using a tablet for playing the game? 1=Nothing, 5=Very much *
Please choose only one of the following:
  1
  2
  3
  4
  5

[] Did you find your character in the global scene? *
Please choose only one of the following:
  Yes
  No
Which minigame did you like most? *
Choose only one of the following:
- Unloading the ship
- Selling the goods
- Building the steaks

Did you take your picture for creating your character? *
Choose only one of the following:
- Yes
- No

Did you follow expert indications during the "selling the goods" minigame? *
Choose only one of the following:
- Yes
- No

Avatar Creation

Please rate the process: 1=Low, 5=High *
Choose the appropriate response for each item:
- Easyness
- Quality
- Usefulness
- Satisfaction with the result

Expert Participation

Please rate the process: 1=Low, 5=High *
Choose the appropriate response for each item:
- Easyness
- Usefulness
MiniGames

[ ] Please rate game number 1: Unloading the ship. 1=Low, 5=High *
Please choose the appropriate response for each item:

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[ ] Please rate game number 2: Selling the goods. 1=Low, 5=High *
Please choose the appropriate response for each item:

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[ ] Please rate game number 3: building the stelae. 1=Low, 5=High *
Please choose the appropriate response for each item:

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<td>Creativity</td>
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Thanks a lot for taking part in our experiment.

Submit your survey.
Thank you for completing this survey.
## Appendix B. QoL Questionnaire

### Questions

1. The visited city of Miletus was located in time:  
   ![Image](image1.png)  
   [Show answers](#)  
   30 Seconds 4 Choices

2. A votive stela is:  
   ![Image](image2.png)  
   [Show answers](#)  
   30 Seconds 4 Choices

3. One of the four main harbour of Miletus (the one for the first game) was called:  
   ![Image](image3.png)  
   [Show answers](#)  
   30 Seconds 4 Choices

4. Which one of the next goods was **NOT** sold in the Agora?  
   ![Image](image4.png)  
   [Show answers](#)  
   30 Seconds 4 Choices

5. Which was the basic unit of Athenian currency?  
   ![Image](image5.png)  
   [Show answers](#)  
   30 Seconds 4 Choices

6. What was used copper for?  
   ![Image](image6.png)  
   [Show answers](#)  
   30 Seconds 4 Choices

7. Which is the name of the main building in the Sacred Way?  
   ![Image](image7.png)  
   [Show answers](#)  
   30 Seconds 4 Choices
Appendix C. Consent Form

INFORMED CONSENT TO PARTICIPATE IN THE PLAYHIST EXPERIMENT

The purpose of this document is to inform you, that you have the status of a volunteer in the experimentation sessions of the PLAYHIST experiment, which takes place within the context of the European project EXPERIMEDIA. You are totally free to participate in the tests or refrain from them. You must sign this document only if you have read it, agree with what is said and wish to participate. By signing, you grant us with the right to maintain and process the information you will be generating through a leased tablet during the course of the experiment, plus your replies to a questionnaire that will be delivered at the end of testing. No personal data about yourself will ever be handled, monitored or recorded.

ABOUT THE EXPERIMEDIA PROJECT AND THE PLAYHIST EXPERIMENT

EXPERIMEDIA is an innovative research project funded by the European Union aimed at studying Future Media Internet technologies. The emphasis is on making experiments with new information services that may provide added value for (typically short-lived) communities in relation to their activities in certain venues. Putting users at the heart, the EXPERIMEDIA experiment attempts to gather information that will help to design future technologies.

The PLAYHIST experiment, designed and carried out by TECNALIA (Spain) aims at enhancing visitor experience in history learning by developing an interactive and collaborative serious game where visitors will be proposed with a mission or set of tasks that must be developed to achieve a specific goal.

You will participate in one of the following ways:

1. You will attend the projection of an interactive film at the Tholos and at the end of the projection you will be asked to fill in a questionnaire using a tablet, about the historical concepts you have learned watching the film.

2. You will play a game following three steps:
   - Step 1. Participants will have to choose a 3D character or avatar for playing the game. It will be possible to take participant’s own picture for creating the avatar. You will have to enter a nick name for player identification
   - Step 2. You and the other participants will be taken to the Tholos for game playing. Using your tablet, you will have to accomplish different mission, obtaining a final score.
   - Step 3. After ending the game, using the same tablet, you will have to fill in a questionnaire about your experience during the experiment and about the historical concepts you have learned while playing.

PURPOSE OF DATA COLLECTION AND PROCESSING

The data collected or logged during the experiment will be parsed in order to draw conclusions about parameters and design aspects that influence quality of service and levels of satisfaction and learning. The treatment will be statistical and not per individual.
Data gathered will include the information you will be generating through the tablet during the course of the experiment if you have played the game, plus your replies to the questionnaire that will be delivered at the end of testing. In case you have played the game and you have chosen to use your own image for the avatar creation, this image will be deleted at the end of the experiment. Your personal details (name and surname) only exist in the present document, which will be kept in the project file and not be available to anyone but the coordinator of the PLAYHIST experiment, Mrs. Rosa Peral from TECNALIA.

RECIPIENT OF THE DATA The data collected or logged during the experiment will only be available to the experimenters and not be used for any other purpose. There is no commercial intention behind the collection of the data, so no third parties will ever be allowed to access them and no transfers will be permitted.

FREE CONSENT I declare that I have read the above, that I agree with the terms and conditions and that I want to participate in the PLAYHIST experiment of the EXPERIMEDIA project.

Name:
Signature: Date:
Appendix D. Equipment Loan Form

EQUIPMENT LOAN

PLAYHIST Experiment

To participate in the experiment a mobile device or tablet is necessary. This device will be lent to you free of charge.

For your part, you agree to maintain the device in good condition and return it at the end of the experiment.

Nexus 7 II Serial Number: ..................................................

Date: ..................................................

Name: ..................................................................................

Personal Identification Number: ..........................................

Signature