TimeMesh: Producing and evaluating a Serious Game

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ABSTRACT
Serious Games are specifically designed to develop mental abilities and skills such as strategy, mental calculation and decision making but the acquisition of deep knowledge is less well understood. The SELEAG (Serious Learning Games) engine is a multiplayer graphical adventure system, inspired by the 90s graphic adventures created by LucasArts. This engine has been used to implement the Serious Game TimeMesh, designed to impart knowledge and competences in the area of History and Geography.

To test the acquisition of knowledge with Timemesh a complete process of evaluation was needed, divided in three parts, always with user intervention: first, with the game developer partners, then with teachers and last but most important with students.

In this paper we present our experience in designing, implementing and evaluating Timemesh as well as the related activities in three european and spanish projects dedicated to this subject. Then we present in detail the results of an evaluation session with students from a school in a small town in Spain and formulate the conclusions.

Categories and Subject Descriptors
L.0 [Assessment/Evaluation/Measurement]: L.3.5—Online Education

General Terms
Design, Measurement, Human Factors

Keywords
Serious Games, Graphic Adventures

1. INTRODUCTION

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with children aged 11-16 in order to determine the value of serious games for this age group and context.

The results that the project produced can be seen at the project website [4].

The second project, SEGAN (Serious Games Network) started in 2012. The main goal is to create a Community of Practice on the Serious Games subject. through a stable (but expanding) consortium to exchange ideas and experiences related to Serious Games. This network is supported by virtual tools and face to face events, in order to increase the visibility and awareness of the benefits and impacts of Serious Games for learning, and contribute to its uptake and efficient use.

The project website [3] contains all the information about it.

The interested reader is kindly invited also to participate in the project. You can register at ([3]) for free and join the discussions, share resources, and so on.

2.2 The results of SELEAG project.

The main result of the project SELEAG is the Online game platform with the three game scenarios. The main characteristics are:

- Online point-and-click 2D graphic adventure, with collaboration and peer gaming
- Online lobby to make teams, select games, talk with friends, etc.
- 3 scenarios for the Industrial Revolution, Maritime Discoveries and Second World War

In fact, upon its use in Slovenia, students and teachers were so interested in the game that they asked for a scene that included Ljubljana as well. Then, a different version of the Second World War scenario was developed, using Ljubljana as one of the focal points of the game play. This also showed that the game platform is extensible and new scenarios can be added to it.

The game is available online at TIMEMESH website. You can register and play for free at ([7])

There are already more than 5000 registered users of the TIMEMESH game. The game has been extensively used in several schools and more than 400 students were already involved in playing it as part of curricular or school activities.

The Game specification and design deliverable defined the guidelines for developing scenarios for TIMEMESH. The scientific and technical parts (state of the art analysis) were used to support theoretically the production of papers and articles about the project. They are also very good theoretical references for researchers and teachers.

The other parts of the report provide the guidelines to design and develop new scenarios. Based on these guidelines, several teachers involved in the teachers workshops have proposed new scenarios, to be developed as curricular activities with their students. Some of these proposals are quite creative and show other possibilities to use the TIMEMESH platform. A few examples:

- Plato's cave (Philosophy)
- Shakespeares life (English Language)
- The 1929 financial crisis (Economy, Social aspects)

- World geography

As part of the game specification, a State of the Art on Serious Games [5] and a State of the Art on Adventure Game Engines [6] were produced.

3. TECHNICAL ISSUES: DESIGN AND IMPLEMENTATION OF THE TIMEMESH ENVIRONMENT

3.1 Game paradigm and architecture

The TimeMesh engine is a graphic adventure online system inspired in the 90s graphic adventures created by LucasArts: the SCUMM approach [2] (see figure 1). Verb-object paradigm is used in this kind of games in which user is in control of a character that walks and interacts with a number of other characters, objects and fixed perspective scenarios. An inventory is also available to store objects that the character collects through the game: the interaction with these objects (combine, inspect or use them with other game elements or characters) is necessary to successfully finish the adventure.

![Figure 1: Verb-Object Paradigm, Example of GUI.](image)

Left: User verb actions. Right: Inventory panel for objects.

User-driven actions are defined by using a click&point approach:

- First click: Some verbs available: Give, Pick Up, Open, Close, Look, Push, Pull, Talk, etc.
- Second click: on an active element on the scenario or the inventory
- Last click triggers an action that can have different consequences:
  - Characters talking, moving.
  - Triggering of conversations with a character that may trigger other actions
  - A new addition to the inventory
  - Adding achievements and flags to an invisible inventory that will unlock further parts of the adventure.
  - Trigger animations
There are cross-bars in the adventure game. A cross-bar is become a team. 4. 2 teams in a pair become a Match 5. 2. Each chapter has 2 versions of it. 3. A set of users A set of chapters a world. A set of worlds, the whole game. divided in scenarios. A Set of scenarios become a Chapter. Multiplayer-Multiworld philosophy: 1. The whole game is were chosen to add to the SELEG engine to support the game. After some analysis, these are the features that an adventure and somehow help each other to advance in a learning scenario were collaborative teams would share a collaborative multiplayer setup. The scenario of use is time that the graphics adventure paradigm is redesigned into features were possible. To our knowledge this is the first 3.2 Multiplayer-MultiWorld Philosophy

The Seleg engine was designed so a number of multiplayer features were possible. To our knowledge this is the first time that the graphics adventure paradigm is redesigned into a collaborative multiplayer setup. The scenario of use is a learning scenario were collaborative teams would share an adventure and somehow help each other to advance in the game. After some analysis, these are the features that were chosen to add to the SELEG engine to support the Multiplayer-Multiworld philosophy: 1. The whole game is divided in scenarios. A Set of scenarios become a Chapter. A set of chapters a world. A set of worlds, the whole game. 2. Each chapter has 2 versions of it. 3. A set of users become a team. 4. 2 teams in a pair become a Match 5. There are cross-bars in the adventure game. A cross-bar is a shared blocking between two teams playing a match. Until both teams have gone through 2 parallel challenges neither of them can progress in the adventure game.

3.3 Management

This structure and relation of players, teams and parings is stored in a the central database and accessed through the PHP layer. However, for educational and safety reasons the filling of the structures is done through the admin-only side of the TimeMesh site. In particular it is the mission of the teachers to create, manage and pair the teams.

3.4 Considerations about the cost of a game

There are certain issues that need to be considered before embarking on the production of a game. In light of the experience gained with TimeMesh, the game that will be described later, the following questions should be taken in account:

- The serious game has been the result of the interaction between academic experts in education (university professors and high school teachers) with game developers.
- Usually the vehicle of communication has been Internet, which made easier to circulate documents between groups and to identify and find development teams.
- During the initial development of the project the need to educate non-game development people about the process of developing games was detected, so an early stage of learning and adaptation was launched. After that the engaged people cold manage these projects successfully, blend game technology and practices correctly with their existing knowledge, and retain the right talent to produce such game results.
- The design team of the serious game range from 5-10 people depending on the task, with three people being completely responsible for the design elements of the project. The programming team was 4 people.
- The project was designed on paper drawings with storyboards.
- The three serious games was build in flash, working on Internet PC¡s and Mac¡n network, running on a central server, accessible in 6 languages.
- The developed time over 18 months.
- The estimated total cost was over 200.000 euros

4. THE EVALUATION PROCESS: WHAT TO ASK AND WHO IS ASKED

A game implementation and evaluation report, that was also produced as a result of SEGAN project, was applied. The evaluation methodology can be seen in detail in [8]. In summary the methodology is divided on three stages:

- First, it was extensively applied to all the implementations. Results allowed validating the SELEG approach but also allowed to validate the evaluation methodology itself.
Figure 2: Overview of our game engine architecture. Left: High-level description of the five systems which compose our game engine. Right: Diagram of the data pipeline, from the authoring tools (Flash and XML editors—blue and green boxes) to the final user.

- Second, it can be replicated for other Serious Games. Therefore, it has been extensively published in conferences and other events.
- As such, this document can extensively reused by other Serious Games projects, even for benchmarking purposes.

Following this methodology, the design process of TimeMesh included three phases. In the first of them a first set of prototypes, including various graphic design styles and educational settings, was proposed to members to be evaluated following the preestablished questionnaire (alpha test). The result was a functional single player first version of the game with three historic scenarios (Second World War, Maritime Discoveries and Industrial Revolution) with quite different design aspect, that was sent to a broad number of educators from all the countries engaged with the project in order to collect a significant number of opinions (beta test).

Finally, the fully operational final version was open to public audience and some gamefests, seminars and sessions of evaluation with students took place (gamma test). The game is still available in Timemesh.eu, and over 5000 players have completed at least one of the scenarios.

4.1 Evaluating within partners: Alpha testing

The objective of an Alpha Testing procedure is to emulate an actual operational testing. It is performed by members of the development team that have not been involved in the development of the particular features to be tested. Alpha Testing allows anticipating, internally, problems that would only be detected by external testers in the Beta Testing phase. This stage is more rewarding if qualitative data collection is used because it provides richer information. Following the evaluation protocol, partners must

1. Identify participants (staff from partners) which have not been involved in the development (at least 4 elements)
2. Have participants playing the scenario and trying to finish it. Participants should
   (a) Measure how much time it took to finish each scene
   (b) Identify learning outcomes addressed. Check if they match watch was proposed
   (c) Identify other learning outcomes that should be addressed
   (d) Assess if the game is motivating. Identify problems
   (e) Assess if the graphical environment / usability is adequate. If not, identify the issues

4.2 Evaluating with educators: Beta testing

Beta testing already involves samples of the end-users that are brought in to comment the game. Focus on the game play, mechanics and interaction with the game allows leaving learning aspects to the last stage, gamma testing performed during the first implementation with the end-users. Following the evaluation protocol, partners must

1. Identify participants (teachers from associated partners: at least 2 per partner)
   (a) Name, school, discipline he/she teaches, e-mail (this info should be collected independently from the questionnaire – nevertheless you can use the questionnaire to guide the interview –)
2. Explain the concept of the game and of the scenario (they won’t have access to the main scenario). Explain how to use the game interface.
3. Have participants playing the game and trying to finish it
4. Participants should
   (a) Measure how much time it took to finish each scene
   (b) Answer the questionnaire
5. Interview the participants using the semi-structured interview guide
6. Report the results
The organization of the study was done as follows:

- Students were seated in teams of two in front of a computer. Students had to collaborate with the teammate to play the game;
- Each team was paired with another team so that they could collaborate online, through the collaboration mechanisms (chat) embedded in the game;
- Before starting the game students answered, individually, a diagnostic questionnaire to assess their knowledge of the facts and ideas of the Second World War;
- At the same time students answered a questionnaire about their competence in History, their motivation towards this discipline and their use of computer games;
- The computers were already prepared, so students immediately entered the game without the need to register themselves or the need to understand the online game platform;
- For this study the first scene of the Second World War scenario was selected due to the closeness to the History curriculum of the students. This scene was designed to take about 45 mnts to be completed by a player with minimal experience in adventure games;
- Students played the game for 45 min. They were monitored (but not helped) by two researchers and a teacher. Teams were allowed to communicate with other teams through the chat or face-to-face;
- In the end students answered the same knowledge questionnaire to assess pre and post-game evolution. Students also answered a questionnaire on their perception of the game usability, play and interest for learning;
- Observations of the two researchers and the teacher were collected in the end;
- Data about the success of the teams in the game was collected automatically by the game platform;

In relation to the use of the game in a normal curricular learning methodology there were a few relevant changes that limited the learning aspects:

- When the game is integrated as a curricular activity, the game complements the normal teaching and learning processes. Therefore there is an added effect of repetition that reinforces the acquisition and retention of the information.
In an integrated curricular learning methodology, the after game can be a class discussion where students present their own views on what they learned from the game. By doing so students can reinforce their own knowledge and can benefit from peer learning by listening to their colleagues.

Both these aspects were absent from this study. Therefore study results reflect probably a lower level of knowledge construction than would have happened in a curricular integration situation.

The knowledge test presented eight questions that (all but one) related to situations and facts that were contextualized in the scene that students played. The last question was intentionally difficult to answer by these students because it is not a common knowledge question and it refers to a specific geographical area (Balcans) that is not addressed in Spanish schools when the effects and facts of the Second World War are studied. By comparing pre and post test answers to this question it was possible to assess if students used any other form of access to information, like a search engine.

The questions asked to the students were:

1. Name two countries that were involved in the Second World War
2. During that time who was Great Britain’s Prime Minister?
3. What was the Enigma machine?
4. What was the importance of the Enigma machine?
5. When was Paris invasion by the German troops?
6. What was the French Resistance?
7. Name one of the words of the French motto
8. Who was the leader of the partisan fighters in Yugoslavia, at that time?

5.2 Results

The results of pre and post-tests can be seen in Figure 3. It is clear from the graph that the knowledge level of the students increased between the pre and post-game questionnaires. This is especially evident in the two questions related to the Enigma machine, the focus of the game. This evidences that contextual information can be converted in knowledge. This is not just factual information.

What students were required to answer related to the nature of this machine and its importance to the war. These are questions that require students to reflect and give their opinion. It is obvious that the answers were not perfect, in terms of accuracy, language and semantics. Nevertheless we have considered as correct all the answers were students showed that they had understood the main ideas about the machine.

The first question is an interesting case. Although all the students gave a correct answer in the pre-game test at that moment only seven students mentioned Germany and France as two of the countries involved. After the game, fifteen students mentioned Germany and France, so there was a clear impact of the game in the way students answered this question.

In the fifth question there was also a curious evolution. In the pre-game answer students mentioned only the year. In the post-game questionnaire, students mentioned the day and month of the invasion. The control question was not answered in any of the situations by any of the students. That shows that students did not tried to answer questions by using other sources of information.

In the remaining questions there was a slight improvement in the number of students that correctly answered the questions.

Overall there was a clear improvement in the level of the students knowledge.

Looking individually at boys/girls differences (see figure 4) we see that the end result is quite homogenous and boys, who had initially worst results, were able to benefit from the game to get at the same level and event better than the girls.
anced what could be expected because the questions were very close in the formulation. It is clear that students are quite neutral about History but nevertheless they prefer it to other disciplines. However they don’t see it as a ‘fun’ subject. The most interesting (and totally unexpected) aspect about this issue is the clear difference between boys and girls. Boys are clearly more motivated than girls to study historical subjects. This had clearly influence in the game development, later on.

Concerning the use of computer games, the predisposition of students towards games was assessed by the following four questions:

1. Computer games are fun
2. I play frequently computer games
3. I can learn through computer games
4. When I have a problem in a game I try to solve it independently

These results can be considered quite surprising (see figure 6). Above all, the fact that students say that they don’t play frequently computer games. It is possible to think that students were reluctant to accept that they play lots of games and therefore lied on this question. Nevertheless in the first question it would be expected that students would be more enthusiastic about games. Therefore this is a group of students for whom games are not fundamental. This can be related to the rural characterization of the village of Mallén which predisposes kids to play more physical activities rather than computer games.

Students were also doubtful that they could learn with games and they are neutral in terms of autonomy in games. This is an important aspect considering that afterwards they would have to play the game collaboratively.

As expected boys were more positive about playing games, they had more experience and considered them more fun than the girls.

About students’ perception on the game, after the game played students answered a questionnaire about their perception of the game. Firstly aspects related to the fun were assessed with the following questions:

1. I liked playing this game
2. This game was fun to play
3. This game did not attract me

The last question was negative to catch students that were answering randomly the questions. Looking at the results of this question (see figure 7) that confirms the previous ones, it was again clear that students answered the questionnaires with intention and honestly.
Serious games are games that exploit the motivation and attractiveness of games for other purposes like learning and skill and competence development. However, to demonstrate the effectiveness of a serious game, an holistic evaluation process is required.

In the scope of the SELEAG project, a serious game was designed, developed and tested, meant to develop and promote knowledge and skills related to history and geography. This game, Timemesh is now being used by more than 5000 students and what we showed in this article was a small part of the evaluation process conducted to ensure its quality.

From our experience, the serious game teams can enhance the playfulness of education by treating the learning process as an exploration field. In each case of our games, there is no prior course content to be learnt. The player or players team start the game with just a rough specification of the general situation to be considered. It has been evident that student-players explore their relations through the process of playing.

A possible challenge of serious games might be to drive the student to actually think that the learning process is a game. Or, it would be interesting to introduce the basic elements involved in game design as an element of the curriculum of the teacher.

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8. REFERENCES