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OPUS: an Alternate Reality Game to learn SQL at university

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Abstract— The project aims to test the effectiveness of applying the principles of experiential learning within a university course. In particular, the objective of the paper is to investigate the educational effectiveness of the Alternate Reality Games (ARGs) and of their characterizing elements: the immersive storytelling, which blends reality and fiction, and the collaborative approach, which activates collective intelligence dynamics. The project combines the concepts of a Database course with the transmedial interaction techniques of a Transmedia course. The idea was to stimulate the interest of Databases course's students in this subject and help them learn and consolidate SQL. The result was the creation of a playful experience that is classified as Alternate Reality Game, a realistic and highly immersive interactive storytelling, set in a likely fictional universe where the basic rule is "This is not a game". The ARG was designed to complement the laboratory practice in the context of a Databases university course. In this way, students can practice, review and consolidate the skills acquired during the course. Furthermore, the playful component is accompanied by on-demand educational content, which players have the opportunity to request when they experience difficulties in solving puzzles that require querying the database.

I. INTRODUCTION

A. Pedagogy of play

Is it possible to apply pedagogy of play in school context? In 2015, Project Zero, a research organization at the Harvard Graduate School of Education, with the support of the LEGO Foundation and in partnership with the International School of Billund (Denmark), started an exploration of pedagogy of play to understand and advocate the role of play in learning contexts. They mapped the terrain of playful learning practices and identified five core aspects of play that can improve and stimulate students learning:

1. Enabling experimentation and risk-taking.
2. Being part of a group, because social components enrich learning.
3. Engaging the imagination to explore ideas.
4. Sense of responsibility in taking appropriate decisions.
5. Play's emotions improve memorization [1].

Pedagogy of play doesn't just apply to children learning. As the Project Zero's researcher Mara Krechevsky says: "Play is a strategy for learning at any age" [2]. The seminal work of pedagogist James Paul Gee has highlighted how game design principles fosters the development of projective identities that

can be profitably adopted in formal education contexts [3] and the relevance of social learning and peer education in multiplayer gaming experiences has been studied by gaming scholars such as Mizuko Ito [4] and Jane McGonigal [5].

B. Alternate Reality Games (ARGs)

What does characterize a well-designed game?

First, a rich and immersive narrative to fascinate and excite the players. Second, a ploy to engage players in collaborative problem solving. These are the core features in Alternate Reality Games, that are interactive media experiences.

The narrative context of an ARG is fragmented on different media, which are connected through explicit or implicit bridges. So, to enjoy and understand all the parts of the story, it is necessary to grasp the references between the different platforms and explore them in their entirety.

ARGs are always set in an *alternate* world, that can belong to past, present or future and that is absolutely realistic. Also, gameplay and narrative are embedded into existing everyday technologies, so the line between what is real and what is not is unclear.

TINAG ("This is not a game", Fig. 1) is the principle of the ARG designers and it is commonly used to describe the tone of these games. The goal is to create an experience where people don't feel like they're playing, even though the storyline may be fictional.



Fig. 1. *This is not a game* claim

Alternate Reality Games can be described as collective social experiences because they invite players to focus on the game universe, overlooking their routine and the distractions of real life. It is a minded game in a network society (real actors, evocative places and fictional challenges) [6].

Players have a central role: they change the rules, they take decisions, they choose what challenges to take and what not and so they define the progress of story. In ARGs players can discover and explore their social identity.

The fragmentation of the plot and the integration into the real world give designers the ability to hide narrative elements.

This invites players to work together to solve puzzles, find clues and achieve the game's objectives. Players have a central role in collect and connect pieces of game's narrative and share them to each other. The "collective intelligence" [7] is a characteristic of this kind of games and it could be helpful to promote socially situated learning. This is the reason why ARGs are potential vehicles for education.

C. Cooperative learning

Cooperative learning, the strategic use of small groups working together to achieve shared learning goals while maximizing individual learning, it has proven to be a highly effective teaching practice for people of any age.

Cooperative learning approaches require group members to take individual responsibility for their own specific task (positive interdependence) and at the same time promote mutual success while working towards shared group goals (promotional interaction).

These techniques are widely used in ARGs because they provide a means for ensuring the interdependence between the game's interactive puzzles by allowing players to individually contribute to achieving the common result.

Thus, the individual contribution of the members can be based on their personal interests and the needs of the group at the same time.

II. PROJECT OBJECTIVES

In the context of university level database courses, supporting students in learning the Structure Query Language (SQL) is a widespread learning issue. SQL requires lot of practice using computer environments, where learners can type queries to solve a list of exercises. In engineering education, competence in database is considered of fundamental importance also for non-computer-science specialists, because it can find application in all branches of engineering, from management to bioengineering, from mechanical engineering to media engineering. The potential target population for an intervention to foster SQL learning in an innovative way is therefore very broad.

SQL is often a difficult language for students to learn, especially for those who are not particularly used to programming [8][9][10][11]. It is based on executable queries used to read, write and update the data present on a database. Large research effort has been devoted in the direction of creating tutoring environments [12][13][14] to support SQL learning.

The present paper describes a different approach from intelligent tutoring system, that is to help students to memorize and practice this language using a playful experience capable to stimulate and involve them as much as possible, using an Alternate Reality Game.

Furthermore, there is the aim of improving and modernizing the university teaching approach by experimenting with innovative methodologies that could be appreciated by students and professors.

For the realization of this project, we investigated what could be the playable aspects of the databases and how they could be implemented in order to stimulate learning. Also

based on James Paul Gee's principles of learning related to video games [15], we found in the ARG the best tool to allow the user to project their individual and collective identity within the narrative universe, so as not to see the queries "boring" or "impossible" as they may seem during the university course, but to make them "a challenge", the puzzle to be overcome to solve the game. The idea is to take advantage of repetition learning of similar but increasingly difficult challenges, combined with collaborative problem solving among group participants.

In addition, this particular form of virtual experience made it possible to integrate the skills and knowledge acquired by the students in the Transmedia course. They would thus have experienced firsthand the theories studied in class in an educational and innovative project.

III. STORYLINE

The main character of the Alternate Reality Game (excluding the users who act in first person) is the fictional Edward Carrols, a former student of the university and founder of the Opus platform, a service designed for graduates looking for a job consistent with their studies. The platform is managed by an innovative artificial intelligence called Ivy, which longitudinally monitors the behavior of members to identify the most suitable job profile not only for the skills but also for the latent aspirations of the candidates.

Opus' posters cover all the notice boards of the university. However, by connecting to the site of the platform, players are faced with a notice that informs of the seizure and interruption of the service for judicial investigations.

Via a code hidden in the poster, the player has access to a message from Ivy with a request for help. The message contains a reference to the chat bot on the Opus Facebook page.

Here the player will be able to communicate directly with the AI and receive the clues left by Edward Carrols himself. Carrols declares himself innocent and the victim of a conspiracy by a multinational that operates in an unclear way, the RSE Nebulashare.

According to Carrols, the RSE Nebulashare intends to purchase Opus with the aim of using the platform's artificial intelligence to guide the political opinions of members, developing persuasive messages profiled on their personal aspirations. Following Carrols' refusal, RSE hacked into Opus' database and the AI, injecting security holes into the system that led to the disclosure of confidential data and thus provoking the investigation that led to Carrols' arrest. RSE has taken over Ivy's database and code and it is working on reverse engineering to go online soon with a new Opus-like service.

The user will have to investigate by thoroughly interrogating the database left by Edward Carrols, to find, using SQL, evidence that proves the innocence of the young entrepreneur.

IV. PROJECT DESIGN

Opus game, as any Alternate Reality Games, is spread over several platforms:

- Posters and flyers that promotes Opus website.

- Opus website, now under (false) seizure.
- Chat bot on Opus Facebook page.
- Three sites to query the Opus database (one for each game step).
- ARize, an Augmented Reality app [16].
- The material of the Database course.

The bridges between the different platforms are shown in the following platform layout (Fig. 2):

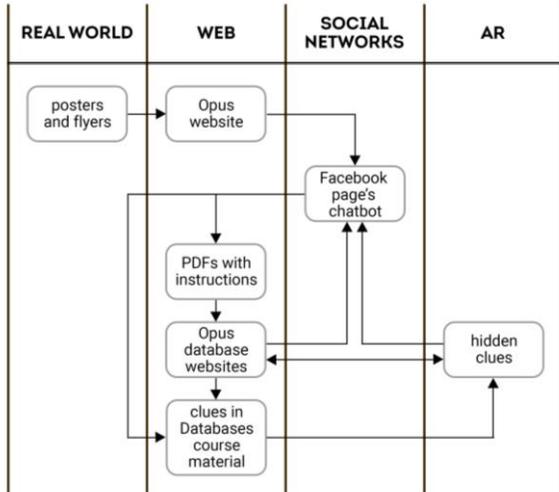


Fig. 2. Opus platform layout

A. The game's sequence

Opus' rabbit hole (entry to the game) is composed of posters (Fig. 3) and flyers that promote the platform for students looking for a job. They contain the link to the Opus website (also reachable via QR code) and the hidden code to start the investigation with Ivy.



Fig. 3. Opus poster

The website (<http://opus320.epizy.com/>) contains a video message where Ivy asks users for help. If they decide to accept, they have to contact her from the chat bot on the Opus Facebook page.

From the chat bot, Ivy will give users three links to three PDF documents with instructions left by Edward Carrols on how to find proves of his innocence in the Opus database.

Each document contains five questions and the link to a website where the questions should be expressed as SQL queries (of increasing complexity) and executed.

The first page of the first website (see Fig. 4) asks players to register as a team or as a single player (although playing in team is recommended for collaborative problem solving).



Fig. 4. First page of first Opus database website

In Fig. 5 we can see how these three websites look like: there are five consecutive pages with an incomplete query where users have to insert the correct missing words to go over.

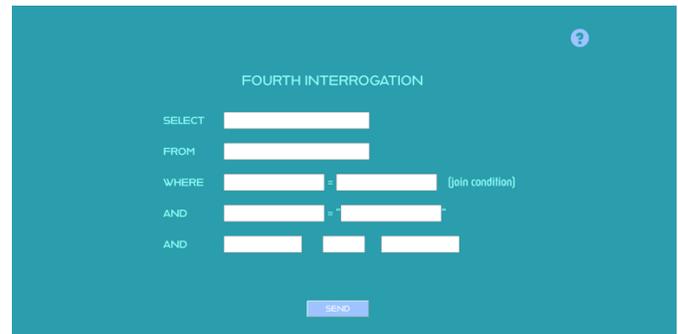


Fig. 5. Example of query input in Opus' database websites

The last query of every sequence will give users a concrete information on the mystery in which Carrols is involved. For example, at the end of the first sequence users will discover the name of the multinational corporation which, according to Carrols, is responsible for his arrest.

The background color of the sequence pages will get darker and darker as players go deeper into the game, as a symbolic accompaniment to their descent into the Dark Web.

The documents also contain the description of the Opus database tables and instructions to download ARize, which will allow players to decrypt some hidden clues.

Finally, there are some clues inserted into the material of Databases course by the teacher. These images have to be scanned with ARize to uncover their clues.

Originally, the idea was to hide the clues in the classroom and the hallways of the university to give the game a more physical dimension, but the current COVID-19 pandemic situation forced the teachers to provide information remotely.

Anyway, students really enjoyed these insertions in the teacher's material which added the adventure of research and realism to the game.

B. How the game ends

At the end of the game, players will find all the evidence to clear Edward Carrols and they will have to inform Ivy about it. The Artificial Intelligence will infiltrate the camera system of the prison where Carrols is a prisoner, connect to the camera where Carrols is framed and share it with players, so they can finally see his face (see Fig. 6). With a secret signal, Ivy will let Carrols know that they made it and that he will soon be released. Then Carrols will thank the players in front of the camera and then walk away.



Fig. 6. Edward Carrols in Opus final video

C. On-demand diegetic teaching contents

The game sequence is quite clear, players are guided from platform to platform and only some information is hidden. However, if they need to practice and consolidate their SQL knowledge, they may need help for completing queries. For this reason, the chat bot contains keywords for all the SQL statements required by the game. To let players know that they can request suggestions, there is a question mark button on the query pages that provides this information on mouse over (see Fig. 7 and Fig. 8).

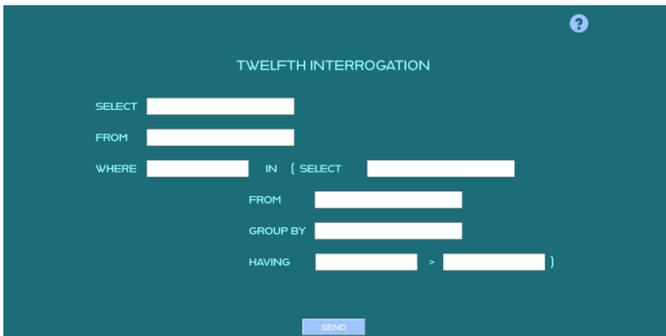


Fig. 7. Example of query input in Opus' database websites.



Fig. 8. Question mark button message.

V. IMPLEMENTATIONS

A. The chatbot

Initially, the chatbot was implemented using the "Chatfuel" tool for Facebook chats.

Later, as a result of analyzing student feedback in the next session, it was manually implemented on a private domain.

In any case, the functioning has remained the same: the AI proposes to the student questions with answer options. The student chooses the answer and continues in the dialogue.

At critical points or following an interruption of the dialogue to allow the student to investigate, the chatbot will ask the player for keywords to be able to continue. This also allows us to be sure that the student has actually completed the previous phase of the game.

Each keyword allows you to unlock the next stages of dialogue with the chatbot that will provide the clues to continue the experience.

B. The queries

Opus asks players to solve a total of 15 SQL queries (5 for each game phase). The queries proposed are of increasing difficulty and only the last of each session provides a clue that is actually useful for the players to solve the mystery.

Query input is not free, both to prevent players from discovering clues earlier than expected and to help those less practical by giving a pre-set pattern to fill in with missing information.

When the players have completed the schemes and press "Send" button, the site composes the query and returns the result from the database, which is printed on the screen.

All the functioning of the site has been implemented using HTML and JavaScript for the front end and PHP for the back end. No tools were used, everything was programmed by hand from scratch.

VI. USER TESTS

A. Test of game's workflow

A preliminary test was carried out in June 2020 in a virtual classroom with students who already took the Database course. About 30 students at the third year of a B.S. tested the Opus game. The goal of the test was to verify that the entire platform

cycle worked and that students understood what they had to do, and how.

The test highlighted some critical issues:

- Initially, the game was meant to be played all in one step. However, this required the player to stay focused for a very long time, compromising the process of understanding the story.
- The narrative rewards (the level of users' engagement with the plot and characters) were not proportionate to the difficulty of the diegetic puzzles proposed, and consequently the motivation of the players was low and a high percentage of players did not complete the game.

As a consequence of these results, the experience has been partially redesigned:

- The pace of play has been redefined, from a single session to three different sessions, with a one-month gap between two consecutive sessions. At the same time, the fictional narrative has been enriched with additional descriptive elements, capable of enhancing the player's experience and facilitating the understanding of the story.
- The transmediality of the project was enhanced, lightening the narrative components delegated to the textual code in favor of audiovisual codes. Audio messages sent by the protagonist to the students were added and a final video was made, in which the main character thanks his helpers for the success of the operation.

This test was very important because it gave the opportunity to have immediate feedback from students to improve the project, so as to have a possible final version in September 2020 to test with the students that start the Databases course in the fall semester.

B. Test of game's effectiveness

A second experimentation is currently underway in the context of two Database courses, one for students at the second year of a B.S. in Management Engineering, and the other for the students at the third year of a B.S. in Media Engineering. The goal of this experimentation is to evaluate the effectiveness of the project in the preparation on examination.

At the beginning of November 2020, the project was described during virtual classrooms and then the students were invited to play the first game session. Students were divided into groups of 3-6 players and very little explanation was given to them about what they were supposed to do, except that they had to work together to solve a mystery.

During the game session, the teachers entered the virtual rooms only when they asked for help.

When all the groups finished, students were asked for immediate feedback, and this time the responses were positive and encouraging. Below is a list of the most significant comments:

"It was fun, especially the clue inside the lecture material."

"It was fun and intriguing."

"It was very interesting having to use different sites and apps"

"I don't think doing it online was limiting."

"It made me feel much like a hacker."

"Engaging and well thought out, it makes you want to continue playing with it in the next episodes."

"Dynamic despite all the game is played sitting on a chair."

The only criticism students made was about the chat bot on Facebook, because some of the students did not use this social network. In this regard, an alternative solution has already been implemented and will be available in the future, as described in section VII.

After this session, the students were invited to play the following two game sessions on their own when they would become available.

C. Analysis of students' feedback

So far only one group of six players (of the ten group that takes part of the second test session) have finished the whole game. We interviewed students about the gaming experience to get feedbacks on their impressions and the effectiveness this project can actually have in preparing them for the course exam.

The analysis will be enriched when the tests are completed and we will have obtained a greater amount of feedback from students. However, the preliminary data allow us to hypothesize some possible positive results with respect to the objectives of Opus.

There were several aspects of the game that we were interested in studying, first of all the relationship with SQL and the topics of the Database course.

We then asked the students if they felt the gaming experience helped them *learn SQL* or *review and apply* it. The answers confirmed the success of our goal, which is not to teach students SQL from scratch but to help them practice it in preparation for the exam. And above all, everyone agreed that an experience of this kind makes learning and reviewing the course topics much more fun and stimulating.

We also asked students if they had used the suggestions feature via the chat bot, if they used them and if they had some comments. They found that the hints were only partially useful, as they were too limited to explaining the SQL statements and not the particular queries required in the game.

They also underlined the aforementioned Facebook "problem", arguing that perhaps it would have been better to insert the chat bot directly into the site, facilitating users who do not have an account on this social network.

After that we were interested in investigating their impressions of the plot and the links between the various platforms involved.

When asked if they found it difficult to get from one platform to another, and all the students denied, saying that the bridges were clear and easy to understand, and that they had no

particular problems in following the logical thread of connection between the various parts.

Finally, we asked students for critiques and suggestions for improving the gaming experience.

One student was absolutely thrilled with the clues hidden in the Database course material, others with the engaging storyline and others with the interface in general.

Everyone agreed that integrating a playful path of this kind into other courses can be useful to stimulate learning.

The adjectives most used by the students to describe the experience were: "engaging", "mysterious", "funny", "interesting", "intriguing".

VII. CONCLUSIONS AND FUTURE WORK

In this paper, we presented a new perspective of university teaching, where traditional teaching is integrated with a playful component. From the obtained feedback, it seemed a really good way to make students passionate and deepen into a subject. This kind of approach give students more possibilities to interact than a traditional class. At the same time, working in teams allow to strengthen social relationships and promote constructive and cooperative learning.

This project is only at its beginning, many improvements are ongoing to give students and teachers the best and most effective possible experience.

The idea is also to extend it to other university courses.

A new version of the chat bot on an alternative custom website is just ready and will be available for future testing with Database students in the Summer 2021, while a new set of query-specific tips is under development and will be available soon to help students with exactly the required exercises.

If the tests will give the expected positive results, we could start designing a new version of the experience to be adapted to another university course and possibly have the students themselves design it, in the context of the Transmedia course for the B.S. in Media Engineering.

A possible future development could be to return to the original idea of hiding the contents in augmented reality inside the university spaces, when they will finally be accessible again, to make the experience even more engaging and adventurous.

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