GAME DESIGN AND THE GAMIFICATION OF CONTENT: ASSESSING A PROJECT FOR LEARNING SIGN LANGUAGE

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Abstract

This paper discusses the concepts of game design and gamification of content, based on the development of a serious game aimed at making the process of learning sign language enjoyable and interactive. In this game the player controls a character that interacts with various objects and non-player characters, with the aim of collecting several gestures from the Portuguese Sign Language corpus. The learning model used pushes forward the concept of gamification as a learning process valued by students and teachers alike, and illustrates how it may be used as a personalized device for amplifying learning. Our goal is to provide a new methodology to involve students and general public in learning specific subjects using a ludic, participatory and interactive approach supported by ICT-based tools. Thus, in this paper we argue that perhaps some education processes could be improved by adding the gaming factor through technologies that are able to involve students in a way that is more physical (e.g. using Kinect and sensor gloves), so learning becomes more intense and memorable.

Keywords: educational game, gamification, storytelling, Portuguese Sign Language.

1 INTRODUCTION

The interest in gaming for educational purposes has increased over the last decade, with researchers identifying key pedagogical features that make good games inherently strong learning tools. What underlies the allure of games? Educational game researcher James Gee [1] shows how good game designers manage to get new players to learn their long, complex, and difficult games. A well-designed game entices players into the “reality” of the game world and keeps them there until the goals of the game have been met [2]. Gee points out that incorporating appropriate challenges that are “doable,” and other widely accepted effective learning principles that are supported by research in cognitive science, are in fact a large part of what makes good games motivating and entertaining [3].

Making these opportunities available to those who endure handicap and disabilities is a core concern in today’s society and a must to promote equity and inclusion. In this work we assess the VirtualSign game model, essentially a new approach to make the process of learning sign language enjoyable and interactive. In this game the player controls a character that interacts with various objects and non-player characters with the aim of collecting several gestures from the Portuguese Sign Language. The character can then perform these gestures himself. This allows the user to visualize and learn or train the various existing gestures. The user interacts with the game through data gloves and a Kinect device. To raise the interactivity and to make the game more interesting and motivating, several checkpoints were placed along game levels. This provides the players with a chance to test the knowledge they have acquired so far on the checkpoints, after performing the signs using Kinect. A High Scores system was also created, as well as a History option, to ensure that the game is a continuous and motivating learning process.

The VirtualSign learning model can be used in formal or informal education by different age groups, and can be introduced in various school or college programs. In a broad educational context, considering that "ludic” is not usually a priority in most activities; in fact a game may be the motivating factor that is needed.

Unfortunately, the production and deployment of educational games is not without difficulties [4], particularly:

- The high development costs and an uncertain market make investment in educational games and innovations too risky for producers;

- Institutions resist adopting innovations and do not want to make unnecessary changes and investments, including the use of new technologies for learning;
- Instructors, institutions and publishers do not (traditionally) want to replace textbooks with educational games;
- The value of specific educational technologies (games, simulations, etc..) have not been proven in many cases;
- Parents and teachers still have very negative attitudes about the use of games in the classroom;
- Games are especially suited to teach higher order skills that are not typically assessed through examinations (multitasking, decision-making, strategic vision, etc.);
- Easy access to computers and the Internet cannot be taken for granted in educational institutions (the case of many developing countries).

In the last decades with the growth and importance of the computer game industry, we witnessed an explosion of research endeavors and studies to better understand what makes a computer game engaging and successful. This has led to a number of theories and outcomes about the design and management of gaming experiences, and has produced frameworks about incentives that motivate individuals to play. Three general "gamification" principles are: mechanics (systems of goals, rules, and rewards), dynamics (the way players enact the mechanics), and emotions (the feelings generated during the gamified experience).

2 GAMIFICATION IN LEARNING ACTIVITIES

Gamification is a relatively new concept that has acquired considerable momentum over the last years [5] [6] [7]. It's a concept that integrates the mechanics of gaming in non-game activities to make these more effective and enjoyable. When used in the educational field, gamification seeks to integrate game dynamics and game mechanics into learning activities, for example, using tests, quizzes, exercises, edugames, badges, etc., in order to drive the intrinsic motivation and foster participation of students.

In this context, we can define game mechanics as the set of rules and rewards that make up game play, a satisfying and highly motivational activity, in other words, making it more challenging and engaging. The most common game mechanics [6] include:

- Points: studies at the University of Chicago show that points are fantastic motivators and can be used to reward users/students across multiple levels or dimensions of a gamified activity. In general people love to be rewarded and, when interacting with a point system, they feel like they have gained something.
- Levels: these are often defined as point thresholds, so the students (or users) can use them to indicate a higher status and have access to bonus content.
- Challenges, badges, achievements, and trophies: the introduction of goals in an activity makes students (users) feel like they are working toward a goal. Normally, challenges should be configured based on specific actions and should include user/student rewards when they accomplish certain milestones with badges, achievements or trophies.
- Leader boards or "high-score table": in the context of gamification, high-score tables are used to track and display desired actions, using completion to drive valued behavior. In intrinsic motivation terms, they are one of the most important features of a game, bringing the aspiration factor to the process.

In a way, educational processes have always used gamification in learning activities by applying scores on assignments that can be considered points. However, this game-based system doesn't seem very engaging for the students; so, in this paper we discuss that perhaps education processes could be improve by adding the gaming factor, and a digital narrative, trough technologies that are able to involve students in a way that is more physical (using Kinect and sensor gloves), so learning becomes more memorable and intense. Also, according to this perspective, the academic graduation may be considered a level achieved and a diploma earned is a form of granting a badge of confidence

[6]. Learning a sign language may be also supported by a game, or by gamified activities, as we did within the VirtualSign project.

3 LEARNING SIGN LANGUAGE

Languages can be oral-auditive when written representations are not used but, instead, all communication is oral. They can also be visual-spatial, with a realization almost natural of signs and visual reception. In this last case we could refer several sign languages used by many different deaf communities spread around the world. These, such as oral languages, have their own grammar that allows distinguishing between sign languages and oral languages. The interest in the Portuguese Sign Language has been showing a remarkable growth, not only by the deaf community that today represents near 150.000 persons in Portugal but also by all the involving community, like family, educators, professors, etc. However, in Portugal not much has been done yet in this field to assist the deaf in their daily lives.

The sign language is usually performed in a three-dimensional space, therefore the support from new technologies is indispensable because it makes possible to reproduce the total perception of the sign, including the movement, the hands location and orientation, the configuration, and also facial and body expressions. The richness of this tridimensional language is not limited by the technical realization of the sign. It also involves a holistic and dynamic characteristic of the communication that is natural to the human being. The hands configuration, location and orientation, are as important as the facial and body expressions that follow the realization of the signs. These aspects could be crucial to distinguish very similar signs.

Similarly to the oral language, sign language has a lexical, a “phonetic” (instead of articulated sounds it has articulated signs), a “phonology” (instead of phonemes, it has elements from different natures that accomplish the same differential function from the words visual form), a syntax, a semantic and a pragmatic of its own. Being characteristic from each country and culture, and not universal, allows describing all the reality that involves us, what we see, feel or think. Considering all the basic principles of the Sign Language expressed above and the deaf community needs regarding the access to written sign language interpretation, we realize all the interest in the development of the Virtual Sign project. Its outcomes will assist the deaf community in accessing the written information through Portuguese Sign Language and vice versa, thus contributing to reduce info-exclusion of disabled persons. Game-based sign learning is part of this more general goal.

4 THE VIRTUALSIGN GAME

This game consists of an interactive 3D model about Portuguese Sign Language, where the player can enjoy playing while learning gestures simultaneously [8]. The VirtualSign Translator has been connected to the game [9] in order to make it more interactive, more appealing, and more effective using the Kinect and sensor gloves. The main objective of this project was to facilitate the learning of the Portuguese Sign Language and to improve the dexterity of those who already know it, making learning a pleasant experience.

The deaf community in Portugal has around 150 000 individuals and yet the digital content available for this community is still rather scarce. With this project, not only we are promoting knowledge for this restricted community, but we are also encouraging other people to learn and become able to better understand this community [10].

The game is played in first person view, so the player controls a character in a specific scenario. Each map represents a level and each level has several scattered objects, through the map for the player to interact with, most of those objects are gestures. All objects collected by the player will be stored in his inventory and can be accessed at any point during the game. Most of these gestures and objects can be used through the inventory; the character will then perform the gesture so that the user can visualize how it is done, either automatically at checkpoints or by clicking them in the inventory. To progress in the game the player must collect all the gestures scattered around the level [11]. The faster the player manages to collect all the gestures the higher his score will be. The player may choose to play using Kinect but he must have first obtained all the gestures in the level and perform them.

Our research showed that there are some projects related to this theme/area but none of them implies an automatic bidirectional translation process in a game as this does, therefore making this project very innovative.

Some of the related work is described below.

A. CopyCat

The game CopyCat is the most similar project in comparison to ours. It consists of a game where sign language gestures need to be executed properly in order to proceed. The movement analysis is done through gloves with sensors. However, the researchers from the CopyCat project have published a video where they show their intention to use Kinect for movement detection.

B. ProDeaf

ProDeaf is an application that does the translation of Portuguese text or voice to Brazilian gesture language. The objective of the ProDeaf is to make the communication between mute and deaf people easier, making digital content accessible in Brazilian Gesture Language.

C. Kinect Sign Language Translator in Beijing University

Researchers in China have created the Kinect Sign Language Translator, a prototype system that understands the gestures of sign language and converts them to spoken and written language—and vice versa. This project was a result of collaboration, facilitated by Microsoft Research, between the Chinese Academy of Sciences, Beijing Union University, and Microsoft Research Asia, each of which made crucial contributions.

D. Faceshift

This application analyses facial expressions, namely, the orientation of the user's head and eyes. The information analyzed by the application is used to animate virtual characters that can be used in videos or games.

E. MoVER

MoVER (Movement in Virtual Environment for Rehabilitation), a Serious Game that simulates physiotherapeutic movements through challenges aimed at performing virtual tasks using the human body. This project was developed at the University of São Paulo.

5 GAME DESIGN

The VirtualSign game design established a set of functional and non-functional requirements of the application [12]. Functional requirements represent the features available to the user.

A. Functional Requirements

The functional requirements were identified in the early stages of development of the project, and include the following: 1. Start Menu, where the player can choose the type of game he wants (with or without Kinect), consult the options or exit; 2. Options Menu, where you can change the graphics quality, volume, save or load the game and see the table of high scores.

The game requirements within the levels are:

- Handling and controlling of the character;
- Interacting with NPCs (Non-Player Characters);
- Consulting the inventory and use the items in it;
- Interacting with map objects;
- Accessing to the above options menu.

B. Non-Functional Requirements

Regarding non-functional requirements, our work focused on the following:

1. Usability

Usability is the ease of use of the application and its accessibility to the user [8]. With this in mind during the project design it was established that the interface should be fairly intuitive, allowing for easy adaptation and learning. The user interfaces must be simple so anyone can use them easily. The character controls are simple, and throughout the game there are explanations of what needs to be done. The accessibility is guaranteed because it is only necessary to run an executable file in order to play while Kinect is not in use.

2. Performance

   The gaming performance is always a factor of the utmost importance, because the response time from the game to the user is always immediate, any delay or decrease of the number of frames per second can affect the gameplay making the game frustrating rather than fun. To maintain the performance this game was tested to never run less than 60 frames per second on a computer. The essential functions must be constantly executed and the code must be optimized to avoid waste of resources. Besides the code, all the factors that constrain the performance of the game should be taken into account, such as textures, bumps, and number of vertices of the 3D models among others.

The connection to the VirtualSign translator is instantaneous and there is no delay from the moment of the translation of the preformed gesture to the moment its receive in the game. Therefore the player won't notice any delays while preforming the gestures.

6 GAME ARCHITECTURE

For this project two applications were developed, the game application in Unity 3D and the interface that connects the virtual sign translator to Unity. The interface was developed in Microsoft Visual Studio. The project was divided into layers, given its high degree of complexity.

At the top level there is the interface. The user can access all the functionalities of the project through this layer. This layer is responsible for forwarding the actions of the user to the next layers. On the lower level there are three layers. The sockets layer is responsible for linking the Unity game application to the Kinect that is why this layer is below the interface in order to provide the layer above with the player input. Another layer of the lower level is the game engine; this layer is responsible for the execution of the game itself, representing the functions of Unity. Finally, there is the business layer, which is where the game functions are available to the player.

For the development of this project it was decided to start with the implementation of the basic functionality and then proceed to the animation of the character, which was later replaced by an animated avatar now available at the GILT research group (Graphic Interaction and Learning Technologies). In the development of this project a draft was first developed implementing the basic functionalities. After having a basic scenario created the development phase of the scripts started. All the translations are handled by the VirtualSign translator therefore it's not referenced in the game architecture as it is a different application. The sockets are responsible for the connection between the two applications and the information is transferred from one to another instantaneously. For this application the official Unity Sockets was adapted, and a window was created where the user could see the connection status. This window is set to run on the thread so it does not directly affect the performance of the recognition application. To make the connection with Kinect the IP address and port are needed. This information is sent to the API and this will make the connection, which will return a message acknowledging the success or failure of the operation. This API is entitled SharpConnect.dll. This DLL file was slightly modified in order to work properly based on the functionalities that were developed. After the connection is established, the information from Kinect is received and analyzed. Then we get the confirmation that it is (or not) the information to be expected. If it is not, then the user will be notified of what gesture he did and which gesture was expected. It will be possible to proceed only when the user manages to perform the requested gesture correctly. He or she has then learned and trained the requested gesture, according to the sign language system.

7 GAME PLAY AND SIGN LEARNING

One of the biggest difficulties in sign language is that there are signs which involve global body movement while others involve only the configuration and orientation of the fingers of one hand. The sources of information that need to be acquired to decode sign language depend on the sign itself and are not always the same. The level of detail is also heterogeneous ranging from wide arm movements

to confined finger configurations. This imposes conflicting requirements on the field of view; it must be large enough to capture the global motion, but at the same time, small local movements must not be lost. Moreover, both hands often touch or occlude each other when observed from a single viewpoint and, in some signs, the hands partially occlude the face. Occlusion handling is also an important consideration. Sign Language recognition includes tracking of the hands, face and body parts, feature extraction, modeling and recognition of time-varying signals, multimodal integration of information, etc.

So, the first functionality to be developed had to be the inventory. This consists of forty-two spaces that are empty upon initialization. With the inventory set up and ready to receive the objects that the user may acquire, the handling of collisions with these objects was created in order to detect when the user is within a reasonable distance to perform the interaction. There are also various non-player characters and interactive objects that will give information to the player about quests he must accomplish in order to obtain new gestures. These quests will ask the player to retrieve a certain gesture and use it in a specific situation, such as using water to put off a fire, where the player will have to perform the water gesture near the fire object in the scene.

There is always feedback provided to the user so that he knows what and when to perform a gesture. Players' scores are incremented during the game as they acquire new gestures. The shorter the time it takes between the acquisitions of two objects, the greater the score. If the delay is less than one minute, one hundred points are acquired, if it is between one and two minutes, fifty points are acquired, if the delay exceeds two minutes, twenty-five points will be obtained regardless of time spent. These gestures are then sent to the game and the player visualizes them on the checkpoints so that he knows whether he is performing correctly or not. When all the gestures of the checkpoint are performed correctly the user can then move on to the next area of the level.

In the digital age, educators and technologists are confronted with significant disruptions: a changing media landscape; the rupture with traditional forms to deliver instruction, as well as, a fast paced development of technologies and their inherent impact on the educational context. The development of the VirtualSign "physical" game is an example of this standing. Nevertheless, this new era brought forward unprecedented possibilities to develop learning and numerous forms to design learning experiences for students with special needs.

8 CONCLUSION

As university teachers and researchers, we wanted to develop a methodology that allows the translation of textual educational content to sign language, and the other way round. This served as a launching pad for the development of applications targeted to individuals with special needs. The first developments were focused on the use of data gloves and the Kinect to recognize the Portuguese alphabet using automatic classification. Connected to this, the gamification framework and the game model aimed at teaching Portuguese Sign Language showed to be viable options in the design of a learning experience, namely that it must be engaging, develop creative thinking and problem-solving skills. All of these have been accomplished and seem to be on high demand if one takes into consideration the dynamic and media-charged context of the learner in our schools and universities.

Assuming that the goal of an educator is to prepare learners with knowledge and skills so they thrive in the "real world," in this case one had first to identify what are the challenges of individuals with special needs, and adjust learning processes accordingly. Our future research will be grounded in interactions with the game and the development of effective learning design principles, in accordance with the context described, and this effort is bound to continue through another project already submitted for approval. The research field of "game-based learning" has provided evidence over two decades that games cultivate essential developmental skills in players, also addressing the integration of learners, and fostering the increased use of engaging applications in a learning environment. The preliminary tests with the VirtualSign game have shown to be a promising effort in this regard, and so we argue that perhaps some education processes could be improved by adding the gaming factor through technologies that are able to involve students in a way that is more physical (using Kinect and sensor gloves), thus learning becomes more intense and memorable.

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