A Serious Game Concept to Enhance Students' Learning of Statistics

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***Abstract*— In this ongoing work, the team intends to present a conceptual serious game as an educational tool to promote and demonstrate the applicability of statistical concepts in day-to-day life and in the decision-making process. The serious game will provide learning content in a game-based environment where students/players interact by applying knowledge in Statistics. There will be no right or wrong answers. Based on the students' answers and choices, the serious game, by a design mechanism, will lead them to different challenges until they reach the end. Students' answers must use concepts acquired in the classroom.**

Keywords*— *Serious Games; Statistics Education; Augmented Reality; Geolocation

I. INTRODUCTION

Studies show that the gap between the so call "digital native" (young people born after the new digital era, around 1980) and the "digital immigrants" (people who were born before the new digital era) is not only due to generation alone, but factors like breadth of use, experience, self-efficacy and education are also essential in describing how people become digital natives [1]. Also, authors' results show an increase use of the Internet for learning activities and latent learning benefits in many online activities as playing collaborative games.

Serious Games (SGs) can be defined as computer games that are developed with the primary purpose to transmit scientific knowledge to students or professionals, enabling the improvement of techniques through virtual practice rather than just entertainment or fun [2-4]. SGs enclose a multiplicity of interrelated areas, like new tools, pedagogies and collaborative approaches.

As emphasized by Backlund and Hendrix [3] in their research, even though there is an increase in the use and development of these games, an analysis is necessary to ensure and to understand SGs' effectiveness and efficiency as pedagogical tools.

SGs can be found and used in a wide variety of areas: from military and emergency services to the different levels of education [3, 5-8], as well as in management, in engineering, in languages and in medicine/health [9-14], Fig. 1.

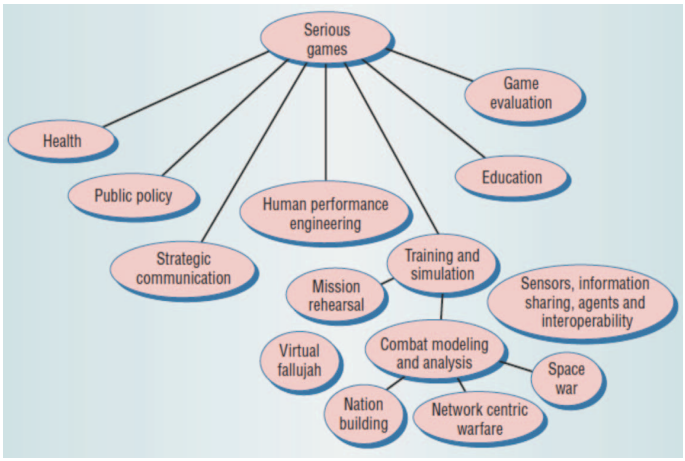

Fig. 1. SG different domains of applications (from [8])

For the game to be considered efficient, there must be a balance between the issue of representation and the gameplay so that play is not only fun but also didactic [15]. Another issue that is being taken into consideration has to do with SGs assessment. This process enables to verify if the game learning goals and objectives are being met [16], as well as to understand in what way students learn and what they learn.

The focus of this ongoing work is to describe the first steps on developing a SG to teach probability, confidence intervals and hypothesis tests, corresponding to the first level on a Statistics course for undergraduate engineering students. Theses topics, even in higher education, are still considered, in some way, difficult, complex and misunderstanding, which points to the opportunity for more effective and practical teaching/learning methodologies [17]. Also, the work described by Boyle and co-authors [18] showed, by a literature review, that the use of a game-based approach might be applicable in learning these topics, although there are still few evaluations. These conclusions can be seen as an incentive to develop games to support the teaching/learning of different skills and to engage students to these topics. Regarding serious games, authors found 5 out of 26 papers, but none regarding the

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probabilities, intervals confidence and hypotheses test representing an opportunity for the development of the SG. Although applied in a different area, the results obtained by Wang and co-authors work demonstrate the benefits that can be gained by the implementation of serious games, encouraging teachers to integrate them in their class as a teaching/learning tool [19]. This work's results can also be seen as a motivation to continue to develop the serious games presented.

This paper is divided in four sections. Section 2 presents the approach adopted followed by the anticipated outcomes, section 3. Finally, the ongoing work is discussed in section 4.

II. Approach

This section presents the general view of the approach to be followed for the design of the SG as well as an example of a scenario or challenge of the SG and the application development.

A. General View

The serious game as a learning tool to support the learning objective must be designed to engage the student/player till the end. So, the game storyboard must have a fascinating, challenge and engagement flow. Through simulations of practical situations of day-to-day life, the game allows the development of certain skills, including attention, memory, and development of thinking and analysis abilities. At the same time, the serious game as a learning tool will provide a better understanding knowledge to Statistics students. This will be done through SG's feedback based on analysis of the information gathered from the students' outputs, decisions and interactions when playing the game. Fig. 2 illustrates the general interactive cycle of information between student/player and the SG, which is considered vital for the success of the SG objectives [20-21].

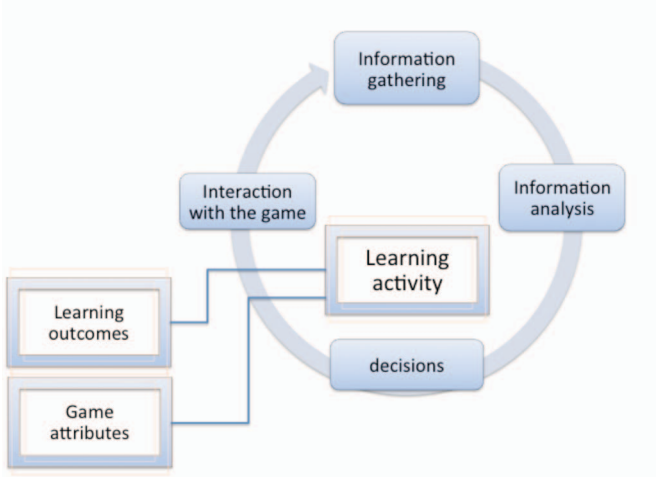

Fig. 2. Scheme of the interactive cycle of information between student and SG when playing

The game concept should follow a modular structure to allow the inclusion of different challenges and scenarios over the time in order to keep the students' motivation and engagement high.

The main scenario should be a challenging environment (storyboard involving crime or espionage, like CSI series, in the university campus) whose clues and decisions are contextualized in the Statistics area by the application of probability knowledge, confidence intervals and hypothesis testing (for example: in DNA identification and fingerprint analysis). Thus, the teaching/learning activities involve decision-making based on these subfields of Statistics, without forgetting, in all the steps of the SG development, the close alignment of the game goals with the module of the Statistics course.

The serious game will run in a "real world" environment, using geolocation and augmented reality on mobile devices with GPS, allowing game scenarios for multiple users/students, interacting with each other and increasing the activity in the course of the game.

The contents of the game are being chosen and they will be mapped to a game structure that will be developed according to game design models in the literature, as for example LM-GM [22] and/or the more detailed ATMSG [23].

B. Example scenario

The game will be divided into individual modules that could be accessed dependently or independently regarding the level of knowledge of the students and/or interest.

The scenes in the game could be from different types from animation, interactive and using video/photos. As previously mentioned, it is planned to develop a story where the main scenario will be a CSI-style. Presently, the first module of the game is under development. Two main places are already defined: (1) introductory place for the presentation of the main character, and (2) the place where the main action unfolds. The introductory place will be a very moving international airport and then switching to the university campus (where the main scene is taking place).

C. Application development

Mobile devices are an ideal platform for the game, since they can be used anywhere, anytime and have sensors that are a key to create an augmented reality environment, such as a camera in the opposite side of the screen, accelerometer, and compass, among others.

Currently, the development of mobile applications can take three approaches: native, mobile web and hybrid. Native apps are single platform and thus are not considered for an exploratory work like this, since the goal is to reach as much users as possible. Mobile web and hybrid apps are both multiplatform, but the former does not allow access to all device capabilities, namely the sensors mentioned above and which are of interest to this work. So, we turn our attention to hybrid apps, which are based on frameworks that use web technologies but allow access to all/most native features.

Besides reaching a wider range of users, multiplatform apps (either mobile web or hybrid) enable to reduce the development and maintenance costs. However, they also have drawbacks, and therefore these aspects have been studied. According to Angulo and Ferre [24] the user experience can be

good if the framework respects the interaction style of the target mobile platforms. Therefore, it is important that the multiplatform framework supports the development of native components to allow closing any eventual gaps. This is particularly relevant for iOS, whose users are usually accustomed to less varied interaction styles. Althi *et al*. also agree that hybrid appearance is less favourable than native [25] but they have used a simple CSS framework for HTML styling and there are currently more sophisticated options. Although, providing a good user experience is key to the success of our proposal, we expect that the mobile users' perceptions towards different interaction styles will change as more multiplatform apps are introduced.

Another aspect of user experience, this one more objective, is performance and, in this regard, in [26] Mercado *et al*. conclude that PhoneGap, one of the most popular frameworks, has variable performance results depending on the target platform, but their evaluation uses only a single app (Facebook). This is to be expected in general, since hybrid apps run on a web view (or embedded browser).

The options for developing hybrid apps are changing rapidly, with new frameworks coming out in the last couple of years (e.g., ReactNative, NativeScript and Ionic 2) and others being discontinued. Therefore, comparative studies become outdated and, according to our search in the literature, there are no studies that include more recent frameworks, namely the above-mentioned examples.

Ionic 2 is a rich JS/Typescript UI components framework supported by a large community. It is based on Angular for the user-interface and Cordova (the base of PhoneGap) for the mobile multiplatform support. Therefore, it follows a MVC/MVVM model and uses a single base code that is *transpiled* to web (view) code tailored for each platform. NativeScript and ReactNative take a different approach, by compiling the web app code to native code that is executed directly on the platform, i.e. outside any web view and independently of browser capabilities. Although both have potential and aim to native comparable performance, NativeScript has less freely available components and a smaller support community, and ReactNative has not yet reached version 1.0. So, we are planning a hand on experiment to decide between NativeScript and Ionic 2.

Since the proposed game intends to create an augmented reality environment, namely combining video from the device camera with graphical objects, a specific 2D or 3D drawing/animation framework might be needed, possibly a game engine framework. Naturally, it must be HTML/JS, to be compatible with the chosen mobile web framework.

Lastly, the game will be multiuser, and support interaction between users, Fig. 3. Therefore, a service is needed to exchange user interactions data with the mobile app. Both the mobile app and the service will store that data when players are offline. To avoid dispersion of programming languages, probably we will use node.js.

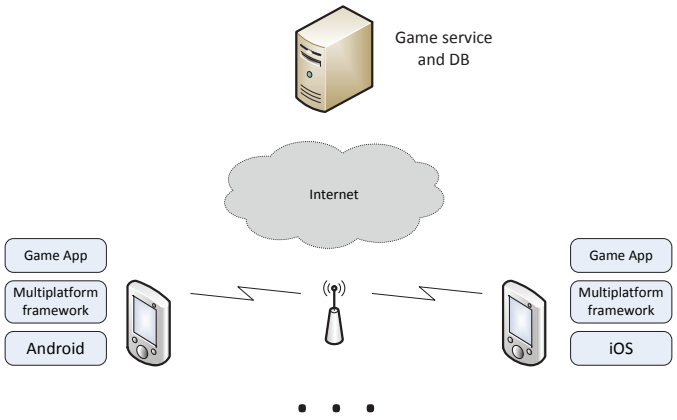

Fig. 3. General architecture

III. Antecipated Outcomes

In order to use the SG as a learning tool, it must provide appropriate feedback to the student/player. As previously mentioned, the clues and the challenges that the SG shows to the student/player are according to the student/player answers and choices, that is, the game must adapt to meet individual needs in a specific topic till be fulfilled. One of the learning goals is to enable the student to develop understanding and capacities to solve problems using basic statistics techniques.

It is expected that the deeper the involvement of the student/player is, the more effective is the delivery of the activities. So, a motivated and engaged student will be a sign of an effective SG. Furthermore, the game should contribute to an increase in the grades and comprehension/learning of the Statistics courses. Also, and since the serious games replicate real world situations in the virtual environment, it is authors believe that students can realize the applicability and relevance of the statistical analysis.

IV. Ongoing Work

This is an ongoing work, and the serious game still is in a conceptual model phase. It is the authors believe that within three months the development of the serious game will be in the next stage.

In parallel, at this early stage, it will be useful to know what our students think about the use of serious games as a learning tool on these topics and what would be the perceptions and impact in their study and motivation. Following this idea, a survey is being developed. This questionnaire will allow identifying if the student plays, the kind of game, gaming frequency and motivations preferences. Later, the results obtained from the students´ feedback will be presented and discussed.

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