Sede Amministrativa: Università degli Studi di Padova

Dipartimento di INGEGNERIA DELL'INFORMAZIONE (DEI)

CORSO DI DOTTORATO DI RICERCA IN: INGEGNERIA DELL'INFORMAZIONE

CURRICOLO: SCIENZA E TECNOLOGIA DELL'INFORMAZIONE

XXX CICLO

Titolo della tesi:

ADOPTION OF THE NETWORK GAMING PARADIGM FOR TECHNOLOGY MEDIATED LEARNING IN EDUCATION

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Abstract

Evolution of ICT and, moreover, gaming contents and technologies, let researchers and practitioners to test and employ new digital learning tools based on interaction. Academies spent a huge effort on this topic: there is a vast literature about applications and serious games playable on interactive spaces/floors, touch screens and other interactive environments, trying to define impact of such instruments in learning. While the positive impact of gaming in learning is widely demonstrated and proofed, there still is a variety of unresolved questions. At the Sound and Music Computing laboratories at DEI, UNIPD, research focused on the potential catalysing role that enactive learning, through full-body movement, could have in a learning process. Experiments were produced to investigate this topic: after the experiences coming from "Stanza Logomotoria" and "Harmonic Walk", also the experience with the "Good or Bad?" game followed this research path. When dealing with discouraging results, the author and his colleagues noticed some flaws in the research approach, that are commonly spread among this research community: the generally short exposure of the test subjects to the game, whose experiences are biased by the "novelty effect" and the poor attention given to the quality of the game experience itself, that results widely far from minimal actual commercial videogame standards. In other words, classic academic approach to serious games treats them as "isolated cases": tracked experiences are limited in terms of dissemination, access (when can be accessed just in a particular place, with the obvious necessity of sharing the instruments with other people) and time. This fact is very limiting in terms of applications' exploitation (game's intrinsic ability to generate a solid long-term engagement on the users/players is wasted). The present study aims at addressing the reported issues by proposing a new educative experience, that exploits serious games and try to break this kind of "isolation", by creating a proper gaming context designed to catalyse its potential. The idea is to import mechanisms and practices that are a *de facto* standard in commercial videogames market (e. g. the successful cases of *Playstation Network*, *Xbox Live* and *Steam Community*): author's goal will be to provide a solution to catalyse players' experience and stimulate a virtuous competition, in order to fully exploit serious games, through achievement systems and a multiplatform approach. In addition, the proposed paradigm will equip teachers with tools to track users' performances, collect statistics and actively join ad administer students' communities. Validation upon students-gamers and teachers' opinions showed an appreciation for the proposed technologies, with some additional requirements and suggestions for model improvement and refinement. These results stimulated the development of a concrete prototype, which is actually under construction (the PONG project).

Sommario

L'evoluzione dell'ICT e del mondo dei videogiochi ha permesso ai ricercatori di sperimentare nuovi strumenti di apprendimento digitali basati sull'interattività. Gli sforzi prodotti in questo ambito sono stati molteplici: esiste una vasta letteratura accademica riguardo applicazioni e "serious games" che sfruttano spazi e pavimenti interattivi, touch screen e altre modalità di interazione, nel tentativo di valutare e definire l'impatto di questi strumenti sull'apprendimento di abilità e nozioni. È stato dimostrato che l'attività del gioco ha un impatto positivo sullapprendimento, anche se alcuni aspetti sono ancora da chiarire ed approfondire: ai laboratori di Sound and Music Computing del Dipartimento di Ingegneria dell'Informazione dell'Università degli Studi di Padova la ricerca si è concentrata sull'apprendimento enattivo, con interazione a corpo libero. Gli esperimenti prodotti nel tentativo di investigare questo aspetto sono stati molteplici, con le esperienze della "Stanza Logomotoria", dell'"Harmonic Walk" e del "Good or Bad?". A fronte a risultati poco incoraggianti, l'autore ha notato alcuni problemi nell'approccio scientifico, comuni anche agli altri lavori del settore: l'eccessiva brevità delle esperienze di utilizzo, condizionate dall'"effetto novità" e da una scarsa attenzione alla qualità complessiva dell'esperienza in sé, di gran lunga lontana dagli standard del mercato. In altre parole, l'approccio classico li tratta come "casi isolati": le esperienze, difatti, risultano limitate in termini di distribuzione, accesso e tempo. Questo lavoro mira a rompere questo "isolamento", proponendo un modello per una nuova esperienza educativa che sfrutti appieno i "serious games" importando le idee e gli standard suggeriti dal mercato dei videogiochi commerciali: lo scopo è quello di catalizzare la piena attenzione dello studente, al fine di sfruttare il potenziale di questi giochi. Il modello proposto prevede la creazione di sistemi di achievement, un approccio multipiattaforma allo sviluppo dei giochi e la creazione di strumenti per gli insegnanti, in grado di tracciare le performance degli studenti, assegnare esercitazioni e essere parte attiva della loro comunità. La validazione stata realizzata sulla base delle opinioni di studenti/giocatori ed insegnanti, con lo scopo di ottenere un modello raffinato di piattaforma. Le opinioni raccolte rafforzano queste intuizioni, le migliorano e incoraggiano la realizzazione di un prototipo concreto (il progetto PONG).

Acknowledgements

Emanuele Contarini, Andrew De Stefani, Antonio Nozzi and "the postman" Claudio Ravara. A huge "family", I know! Well, guys, before I said that "this work is mine", but the truth is that this work is also a little big bit yours, so I dedicate it to you!

Publications

International and National Conference Papers

1. M. Mandanici, A. Rodà, S. Canazza and F. Altieri. The "Harmonic Walk" and Enactive Knowledge: an Assessment Report In Proc. of the 12th Sound and Music Computing Conference Maynooth, August 2015

2. M. Mandanici, F. Altieri, A. Rodà and S. Canazza. Listen, Move, Learn: full body interactions in a music learning floor camera space. MET16 –Music, Education, Technology Proceedings London, 14–15 March 2016

3. A. Rodà, F. Altieri, M. Mandanici, N. Pretto, S. Canazza. 'Good or Bad?': an Augmented Reality Game to Engage Users in Active Music Listening Tasks. EiED 2016 –6th European Immersive Education Summit

4. F. Altieri, M. Mandanici, S. Canazza, A. Rodà, E. Menegatti, M. Munaro. 'Good or Bad?' Potenziare L'ascolto attivo mediante spazi interattivi CIM16 –XXI Colloquio di Informatica musicale

Submitted Journals and Conference Papers

1. F. Altieri, M. Mandanici, A. Rodà, S. Canazza. Content Delivery and Training Through Playing: a Networked Multimodal Platform for Full Exploitation of Serious Games. –special issue on Mobile Assistive Technologies (MAT) of Hindawi Wireless Communications and Mobile Computing

2. M. Mandanici, F. Altieri, N. Pretto, M. Munaro, A. Rodà, S. Canazza, E. Menegatti. The "Good or Bad?" Game: Stimulating Listening Skills through Playful Engagement and Full-body Interaction. –Entertainment Computing.

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Chapter 1

Introduction

Being the last is not dishonourable. It's better to be the last rather than without dignity.
- Zdenk Zeman

1.1 Education and challenges from the digital revolution

It's a matter of fact that world has drastically changed due to effects of "Digital Revolution". Informations and news, nowadays, travel from one side of the world to another at a speed that was unthinkable four decades ago. Digital age expanded our reality, filling it up with new services, devices, media and interaction paradigms. Education world had to deal with this in order to keep up with times. Collins and Halverson (Collins and Halverson, 2010) observed how both public and private education institutions reacted to this phenomenon, stating that education is actually changing and shifting its paradigms in order to embrace this revolution, just like it did at the times of various industrial revolutions. When talking about education paradigm, it means that the education world is changing what to teach, where to teach, how to teach and how students learn: Siemens (Siemens, 2005) stated that the classic leaning theories of Behaviourism and Constructivism were not enough to deal with the new digitally-enhanced learning mechanisms, so he defined a new discipline, the Connectivism. "*Connectivism is the integration of principles explored by chaos, network, and complexity and self-organization theories. Learning is a process that occurs within nebulous environments of shifting core elements, not entirely under the control of the individual. Learning (defined as actionable knowledge) can reside outside of ourselves (within an organization or a database), is focused on connecting specialized information sets, and the connections that enable us to learn more are more important than our current state of knowing.*" (Siemens, 2005). One of the most popular strategies in this direction consists in the adoption of MOOCs (Pappano, 2012). The acronym stands for **M**assive **O**pen **O**nline Courses and actually represent a way to grant access to knowledge and courses via Internet. Basically, MOOCs act like both a support and a kind of "2.0 revision" of traditional courses delivered by institutions. These platforms provide a place where teachers can deliver material to their students in a very efficient and quick way: moreover, they can reach huge audiences simultaneously, bypass-

ing all the spatial and logistical limitations of a traditional approach via traditional classrooms. MOOCs also represent a virtual place where all education actors can virtually meet, exchange opinions, ask and reply for elucidations, organize assessments and verifications. In other words, idea behind MOOCs is the digital enhancement of the classic educational institutions, in order to improve content delivering and let students access course materials in a quicker and more efficient way, reaching also wider audiences. On the latter years, however, there was an increasing effort on trying to update and adapt educational tools to the (young) students' world and reality. *Edmodo* (Balasubramanian et al., 2014) is a project that aimed to define a proper social network tweaked for education, with the clear goal to catch young students' attention with an environment similar to most popular commercial platforms (like the most famous and widespread one: *Facebook*) but oriented to learning, so safe from all their typical risks (e.g. cyberbullysm and inappropriate or unfocused contents). Beside this, researches also started to focus on how to improve lessons through interaction and gaming: digital revolution brought a huge amount of new interaction paradigms to deal with, like WIMP and post-WIMP interfaces (defined by Van Dam in his "*Post-WIMP user interfaces*", van Dam (1997)), touch-screens, interactive floors and spaces, videogames, augmented and virtual reality. Researchers spend a lot of effort to test these instrument inside a learning context (see chapter 2), in order to evaluate their efficiency in terms of teaching power and student's engagement. Since decades, gaming have been certified as a fully legitimate instrument of learning (Rieber, 1996), so also digital gaming was considered as a proper way through which to deliver knowledge and train abilities.

1.2   Motivation and research approach

Experiments and researches in learning through serious games and various access methods, including physical interaction and motion tracking systems, has produced a huge and heterogeneous collection of works. These works studied various aspects of the educative experiences of serious games: besides the "simple" (and acquired) demonstration that gaming and, more in general, *gamification* (Deterding et al., 2011) lead to higher learning efficiency than traditional teaching methods, researchers deeply concentrated on how single game elements (e. g. a particular interface, a particular feedback system, a particular access method...) give their contribution in terms of engagement, affection, learning power, usability and so on. However, despite the enormous quantity of effort spent, some questions are still open and without clear and unquestionable answers. During my Ph.D. studentship course at the Sound and Music Computing Laboratories of the department of Information Engineering at the University of Padova, I had the opportunity to participate in research about the role and the impact of physical movement in serious gaming. Following the path set by Zanolla (Zanolla et al., 2013) and Mandanici (Mandanici, 2016), we addressed this aspect by testing a new educative application, the "Good or Bad?" (see Chapter 3), and investigating the role of physical interaction in our projected floor equipped with a motion-tracking system. However, results coming out from experiments were quite discouraging: they failed, in fact, to provide a reasonable and clear answer to the research issue. This fact was due to some research approach flaws, common also to works coming from other researchers and institutions: there is a lack of investigation about impact of such technolo-

gies on the long run (generally, monitored experiences are no longer than few weeks) and they also tend to ignore commercial videogames standards. Videogames market radically switched its paradigm of content delivery and customer affiliation since more than a decade. It is a strong opinion of the author that serious games' universe and researchers cannot ignore this and remain (as will explained in chapter 2) anchored to an outdated vision. Starting from this, this work tries to propose a new paradigm of interactive educative experience that enhances serious games with the adoption of best practices inspired from the commercial videogames market. The process tried to consider exigences coming from both "fronts" of stakeholders, the students-players and teachers. On one hand, the attention was on elements and characteristics that improved gaming experience in terms of engagement and fun and they were identified in achievement systems, standings and easiness of access. Then, this outcome was validated through a survey for students/players, asking them which of the novelties introduced by actual gaming context services are considered pillars of their experience. On the other hand, a collection of tools and instruments of control were defined for teachers: within this new paradigm, in fact, the teacher must be an active player, but not equal to students and with precise instruments of control, in depth performance measurement and behaviours administration. Author asked teachers' opinions and requirements to effectively define and tweak a tool suitable to utilization in a real scholastic context. By considering outcomes coming from these surveys and interviews, the theoretical model was defined and a concrete prototype is actually under construction (the PONG project). Further steps will be the refinement of such prototype and effective on-the-field testing within a scholastic context. The final and ambitious goal is to provide a solid framework to support and catalyse long-term engagement of serious games: this have been recognized, in fact, as the key factor to keep high interest in a game (Febretti and Garzotto, 2009), in order to motivate players to play over and over on the long run. Supported by these outcomes, the author strongly believes that the proposed model could deeply renew the interaction with games and interactive technologies in schools: in particular, serious games could become an integrating part of the educational activity and a proper instrument of learning and training. Moreover, this framework stimulates and increases confidence with various kinds of devices and media, turning into a great chance of improvement of a proper fruition of these instruments, both for students and teachers.

1.3   Organization and summary of contents

The thesis is organized as follows. After this brief introduction and exposure of author's intent, Chapter 2 will give an excursus on the literature about interactive applications with interactive spaces, introducing works produced at the Sound and Music computing laboratory of the Department of Engineering of Education of the University of Padova (detailed then in Chapter 3) and will talk about the problem addressed by this work: the study of serious games within a gaming context service. After a preliminary discussion of which are the aspects of the commercial experience that looks suitable to be imported to the educative one, there will be an exposure of stakeholders' opinions (Chapter 4): this will be based on interviews to teachers and passionate videogame players. Following these outcomes, the model is refined and proposed in Chapter 5, that resumes the outcomes from this work and then declines which will be the further develop-

ments of this project.

Chapter 2

Videogames in education and learning

The goal of this chapter is to provide an overview of the literature about the core of this work, focused on three main points. The first covers the actual state of interactive applications utilization in pedagogical contexts, the second resumes researches about interactive spaces (trending topic at Sound and Music computing group at the Department of Engineering of information at the University of Padova), while the last part is about actual studies on the phenomenon of commercial integrated gaming systems like *Xbox Live* or *Playstation Network*, explaining what those system are and how they impacted the videogaming experience.

2.1 Videogames and education

2.1.1 Motivation

Extensive research in play in both children and adults showed that play is a very important mediator for learning and socialization. Rieber (Rieber, 1996) stated that play is a fully legitimate and powerful instrument within instructional technologies. Play can be seen as a process of continuous progress and improvement that aims at learning and improving abilities, in order to satisfy particular psychological or social needs. In his work, Rieber provides also various guidelines and theoretical frameworks to design playful interactions meaningful for instructional purposes. In particular, he focused on the concept of "microworlds", a typical element of the constructivist learning theory. As recalled by Siemens (Siemens, 2005), Constructivism is a learning theory where the learners are not treated as a mere empty vessel to be simply filled with knowledge: they actively attempt to create meaning, select and pursue their own learning by trying to understand their experiences. With this theoretical framework, "microworlds" are defined as small, but complete, versions of some domains of interest. Learners do not simply study a domain within a "microworld", they are able to "live" it, like a student of foreign languages can "live" a language by living in the country where it is spoken. A videogame, then, can be seen as a computer-based "microworld" (which must not be confused with computer aided simulations, that have different purposes): the gaming element can be the motivation catalyst that an instructional technology designer looks for. In fact, Rieber argues that "the learner may not be interested in choosing

initially to participate in the activity or may not choose to persist in the activity for the extended period of time at a meaningful level". In other words, "the learners must find the activity to be intrinsically motivating", focusing on the fact that motivation to play is always a key factor for designers, in order to create a valuable product. Amory et al. (Amory et al., 1999) found out that "for games to benefit educational practice and learning, they need to combine fun elements with aspects of instructional design and system design that include motivational, learning and interactive components". The world of videogames dedicated to "more than simple entertainment" defined a brand new category of games, the "serious games" (according to Ritterfeld et al. (2009) p. 6): in our specific case, the goal is to teach concepts and train abilities of students.

2.1.2   Serious and non-serious games in education

In 2007, Kirriemuir et al. (Kirriemuir and McFarlane, 2007) tracked an exhaustive balance of game utilization experiences and tests in an educational context. Researchers stated that the utilization of commercial videogames didn't showed encouraging results in educational context: the evaluation of suitability for the statutory educational curriculum and of delivered contents accuracy is very difficult and unreliable, due to fact that commercial games contain lot of content which is irrelevant and unfocused for educational purposes. As a consequence, commercial videogames met the ostracism of various traditional school stakeholders. Actually, the example of *Minecraft* looks to be able to overcome these problems, as reported by Short (Short, 2012). *Minecraft* is a successful and very popular *sandbox game* created by Makus "Notch" Persson: by providing a free, open and fully customizable world, it lets educators and researchers to try to exploit it for educative purposes. Short, in fact, talks about the use of *Minecraft* in classrooms to teach Maths, Physics and Chemistry. Despite difficulties, both teachers and parents recognized the positive effect of videogames on the students, realizing they could be powerful tools to enhance their abilities in communication, planning, strategic thinking, applications on numbers, negotiating skills, decision making and data handling. In response to that, a lot of effort have been spent on designing serious games with a precise educational purpose: unfortunately, most of commercial tries failed to propose an engaging experience to the students-players. Major lacks were in game difficulty (games were too easy and simple, to be sure to be suitable for everyone's ability level), variety of action, scarce or absent sense of progression (fundamental in a game), loss of the focus on the goal to entertain the players. *Mario is Missing* [1] published by Nintendo for the Super Nintendo console system, was a clear example of this (figure 2.1). In this game, the player acts as Luigi (Mario's brother, according to the *Super Mario* universe), who has to look for Mario (who was kidnapped by Bowser) across a variety of real world cities (such as London, Moscow, New Delhi and others): when visiting these, the player has to navigate inside them and look for the other characters of the Super Mario universe (such as the Toads and Princess Peach) and answer quizzes, enigmas and puzzles related to the historical and cultural highlights of the visited cities. The game, however, quickly exhibits its very poor entertaining factors: the platform-like city exploration model becomes quickly senseless, boring

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[1] `https://en.wikipedia.org/wiki/List_of_Mario_educational_games#Mario_is_Missing.21`

Figure 2.1: *A screenshot from Mario is missing game.*

and deprived of those elements that let the *Super Mario* brand to become strongly successful and mark a milestone in videogames history. A further try was made by the same developers a few years later with *Mario's Time Machine* [2], but the results were not better than the predecessor and, most important, commercial results were poor. The *Carmen Sandiego* [3] franchise games remain the best example of successful educational games (not only videogames) that last since more 30 years. Carmen Sandiego is the chief of a famous mob of thieves: the player acts as an INTERPOL detective that has to travel and explore the world in order to collect clues and catch her (figure 2.2) while being immersed within historical and artistic notions of (virtually) visited placed. Many thousands of other examples could be made: during the second half of the 90s many small software houses released products that remained unknown to the mass market, even when the idea behind the game was appreciable. *Opera fatal*[4], for example, was a graphic adventure, where the player acts as an orchestra conductor who has to reconstruct the musical score of an opera before going on stage: the game, through puzzles and enigmas, delivers notions about musical instruments and history of music. *Opera fatal* is a clear example of serious game with a good idea and structure, but that failed to reach a wide audition due to its technological limitations (it was designed to run just on a *QuickTime* environment). As mentioned before, on the recent days came the experience of *Minecraft*, which led Microsoft to develop a dedicated version called *Minecraft Education Edition* For what concerns academic works, Connolly et al. (Connolly et al., 2012) performed a systematic literature review. The researchers stated that a lot of effort have been spent, with more than 7300 papers hit by the search terms and 129 exam-

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[2]https://en.wikipedia.org/wiki/Mario's_Time_Machine
[3]https://en.wikipedia.org/wiki/Carmen_Sandiego
[4]https://en.wikipedia.org/wiki/Opera_Fatal

Figure 2.2: *A screenshot from Where in the world is Carmen Sandiego? game (1985, Commodore64 and, in the next years, also other platforms).*

ined papers. Statistics showed a general lack of scientific approach on the evaluation of affective and motivational outcomes of such instruments: most of the results, in fact, rely on surveys and probably deserve a more solid evaluation through a properly empirical scientific approach. On the other hand, there were encouraging results on the enhancement of knowledge acquisition for students. Cameron et al. (Cameron and Dwyer, 2005) showed that, on teaching notions about heart attacks, the students exposed to a serious game had significant statistically stronger results when the game had an elaborative feedback mechanism respect to the control group who did not used any game and the one that did not have any elaborative feedback mechanism. Again on this aspect, Yip and Kwan (Yip and Kwan, 2006) showed significantly greater improvements on vocabulary learning when students were trained with carefully chosen on-line games: 70% of the test subjects (student of engineering courses) found the game enjoyable and helpful. This research, moreover, contains another important outcome about the introduction of a simple high score table: "The informants had the will to win and break records and therefore would be driven to play the games again". In addition, "although some said the repetition could gradually become boring, they admitted that repetition of the words in the games helped them to remember the words", so "the simplicity of the games also enabled them to develop confidence": this is a key factor that reinforce the author's idea that a mechanism to encourage and support the motivation for playing could be an important catalyst for learning in an interactive context. The same good results on learning empowerment came from Miller et al. (Miller and Hegelheimer, 2006), who showed that students who received mandatory assessments on the educational game outdistanced performances of students who had no game or had a voluntary game utilization (the topic was, again, vocabulary learning). Once again, this result shows clearly what is the point of the author: if the level of voluntary game utilization had been equal to the mandatory one, there is a high probability that these student could reach the same knowledge level as their colleagues who received mandatory assessments. This means that the game itself failed to motivate the players,

so, without constriction, the advantage on learning the desired skill vanished. Resuming, all these projects and initiatives share some common characteristics:

- software is often developed by the authors of the work and focused on the experimental needs of the work. When not developed by the authors, software is searched on the web, without taking much care about who developed it (if professionals or just amateurs) and its purposes. In fewer cases, the researchers tried to disseminate knowledge through commercial video-games (e.g. in (Miller and Hegelheimer, 2006) it was used *The SIMs* from Electronic Arts);

- there is a general lack of attention to the gaming context, that have been showed to be a key feature of contemporary commercial videogames. The trend is to provide to selected groups of test subjects a series of individual experiences with a specific game, without caring so much about engaging and motivating them: experiments from Yip and Kwan (Yip and Kwan, 2006) showed that a key factor for the success of their work was the motivation provided by the most basic form of player community, a score ranking;

- there is a general lack of research about effects of the serious games on the long run. There is a lack of scientific observation of what should be the impact of such technology as a commonly used educational tool. In other words, the experiences reported are often limited in terms of space (when the game is not accessible via web, but just installed in some particular machines in a particular place) and time (no scientific observation on the long run): this turns into a waste of games' potential.

On the latter point, there is a consistent research literature that talks about projects of student meeting places virtualization, by exploiting the *Second Life* platform and similar and derivatives (figure 2.3). *Second Life* [5] is an online 3D virtual world developed and launched by Linden Labs in 2003. In this platform, users can act with their own 3D avatar in a virtual world, creating a sort of parallel life (a *Second Life*, as recalls the name of the product). The period across the first two decades of the XXI century was the best for *Second Life*, in terms of popularity and registered accounts: in 2013 the active user base hit its peak and was estimated in 600000 accounts[6]. The platform resulted quickly attractive for researchers. In the field of education and learning, the literature production is massive: Baker et al. (Baker et al., 2009) showed the potentialities of such an instrument related to the world of education, while the work from DeLucia et al. (De Lucia et al., 2009) focused on the creation of a virtual campus where students could meet and learn in a virtual space. *Second Life* is also mentioned as a successful instrument to enhance inclusion of students with socialization problems or cognitive disorders (like autism (Conklin, 2007)). However, the inclusion of the works based on this platform is not fully related with the scope of this work, because, according to the game definition provided by Salen et al. (Salen and Zimmerman, 2013) (chapter 7), *Second Life* does not meet all the requirements to be defined a game: in particular, everyone could just try by his/herself (even with a short session of usage)

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[5]https://en.wikipedia.org/wiki/Second_Life
[6]http://nwn.blogs.com/nwn/2013/04/second-life-facebook.html/

Figure 2.3: *A screenshot from a virtual classroom in Second Life.*

that *Second Life* lacks totally in "conflict" (there isn't any form of contest of power or competition) and "quantifiable outcome" (there isn't any mechanism of player evaluation and rankings or victory/defeat condition) aspects. So the author is convinced that any classification of *Second Life* as a *MMOG* (Massively Multiplayer Online Game) or a "serious game" is erroneous and misleading. On the most recent years, new ideas of learning enhancement through games rose up. *Kahoot!*[7] (Dellos, 2015) is one of the actual most successful experiments in this direction. *Kahoot!* platform works in a very simple way: both students and teacher have their own device, connected to the *Kahoot!* server and, while teachers defines a collection of quizzes with 4 possible answers each, students have to answer by tapping a coloured square, like in a contemporary quiz show. This turns out into a fun competitive game, where students are encouraged to improve themselves: the quicker and more accurate they are, the higher the score they get.

2.2   Serious games and new form of interaction

One of the major utilizations of serious games in academic works is research about new form of interaction. Games were employed to verify impact of touch screens, interactive spaces and various form of interaction on gaming and learning. This is one of the trending topics at the Sound and Music Computing Group at the Department of Engineering of information at the University of Padova. The research topic is resumed here in order to introduce the research environment where this work was developed. The basis of the research about responsive floors, as well as, in general, interactive spaces, were thrown long time ago, on first Engelbart's works at XEROX Parc.

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[7]https://kahoot.com/

2.2.1 Origins of the research field

Doug Engelbart[8] started to investigate the human-computer interaction field in 1962 and he was an absolute precursor, who strongly believed in a co-evolution of technology and human capabilities (Engelbart, 2001). In the eighties came media spaces: the growth of the availability of video technologies led to the first experiments of remote real-time video-conference. Hole-in-Space (1980) was, in fact, the ancestor of actual products: a real-time video/audio communication system between Century City (Los Angeles, California) and Lincoln Center (New York City, New York) allowed people to meet, see, and speak as if they were in the same place. Further research at Xerox PARC led, in 1993, to the creation of *Media Spaces* (Bly et al., 1993): the system let people in remote places to work together as if they were in the same room. All these works incarnate the true essence of remote computer communication: the will to provide a virtual shared common space where people could interact, work and and share contents even if not physically in the same place. The paradigm of devices usage shifted from a closed, "self-sufficient" approach, with all the resources in place for an autonomous single user utilization, to an interaction with others, with the necessity to deal with a community and the relative social relationships. This concept was expanded some years later by Bill Buxton with his *UbVid* project (Buxton, 1997): a system of rooms equipped with cameras and monitors organized in order to obtain visual data available at different sizes and locations. *Active Desk*, developed at the *Ontario Telepresence Project*[9], consisted in a large shared drafted table where it was possible to manipulate a shared content with a stylus or a keyboard. Buxton stated that "the box into which we are designing our solutions is the room in which you work/play/learn, not a box that sits on your desk", because "every device used for human-human interaction (cameras, microphones, etc.) are legitimate candidates for human-computer interaction". Produced output is the digitally built object displayed on the desk. These ideas formed the technological basis of responsive floors, that recreate a virtual environment on a segment of floor, equipped with user tracking systems (cameras, but also touchable surfaces). The philosophic framework behind responsive floors must include also the concept of *Ambient Intelligence* (AmI), which is the result of the crossing of ubiquitous computing, ubiquitous communication and user adaptive interfaces. From another point of view came the work provided by Myron Krueger, an American computer artist and researcher: he is considered the father of interactive art, of the concept of "artificial reality" and of free interaction in responsive environments. He started a research work to overcome the limitations in human-machine interfaces and developed new different interaction modes. With his very first projects, *Glowflow* (1969) and *Metaplay* (1971) (Krueger, 1977), Krueger introduced the concept of "interactive art" and proposed the guidelines for the development of the paradigm. *Glowflow* consisted in a dark room, equipped with a sensitive pad on the floor: depending on user's footsteps, the system defines illusory spaces using glowing lines of light. In *Glowflow*, the artist "talks" with the user through a system of image transmission. Inside the room of the installation, artists' image was superimposed with user's images, with a variety of possible interactions. Thanks to these works, Krueger understood that, in interactive art, aesthetic evaluation is focused more on quality of interaction than in audio-visual content: this must be chosen in order to be compatible

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[8] http://dougengelbart.org/
[9] https://www.dgp.toronto.edu/tp/tphp.html
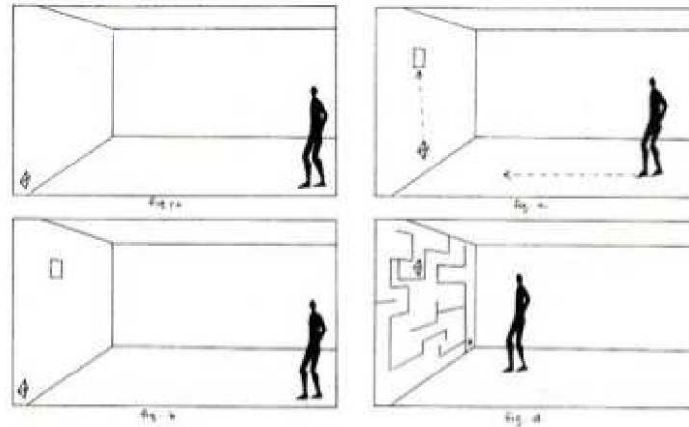
Figure 2.4: *Physic Floor's visual environment reacts to the user's movement.*

with desired conceptual relationships to communicate. These projects opened to the deployment of *Physic Space* (1971), the first ever known responsive floor. The technology was built using a room whose floor was equipped with force sensors. The environment could be used as a virtual musical instrument (the floor was mapped as a virtual piano keyboard) and a visual experience that reacts to the user's movement (see 2.4). These two examples of interactions contain the seed of Krueger's idea of interaction with an intelligent machine, showing how user could get engaged and stimulated. Through the mechanism of interaction with audio-visual feedback, a lot of opportunities opened. That's why, in 1974, Krueger gave birth to *VideoPlace*. Idea behind *VideoPlace* is the partition of an interactive space into sub-spaces, each one with its characters, audio-visual environment and rules. VideoPlace consisted in a couple of dark rooms, not necessarily adjacent: in each one there was a rear camera and a rear-view projected screen showing user's own image in real size and the image of the other user in the other room. Users, through this, are able to communicate: while they are physically separated, they could manipulate the images though movement and video processing algorithms (Krueger, 1977). *VideoPlace* then evolved into *VideoDesk*, where the operative area was limited to a desk with a ceiling-mounted camera.

Mandanici, in (Mandanici, 2016) performed an exhaustive overview about Krueger's work and legacy: in particular, she focused on interesting speculations about reactive environments' employment in the fields of education, psychology and psychotherapy. For what concerns education, Mandanici stated that Krueger was able to forecast and see "the high learning power of reactive environments and the use of physical movement as the interaction modality. By anticipating the theories of enactive and embodied learning, Krueger observes that in our schools learning is a sedentary activity imposed to naturally active children. He suggested that the exciting experience of intelligent interaction combined with physical movement could have a tremendous learning power. However, the design of learning environments should not be limited to automate traditional learning subjects, but should be aimed at changing the learning process dramatically. Since the environment can convey conceptual relationships which can be changed in a mean-

Figure 2.5: *Two researchers trying Tangible Tiles.*

ingful way, it should be possible to create simple interactions which enrich children's learning experience".

2.2.2 Interactive spaces today: an overview

The experiences mentioned here are platforms developed for learning through entertainment and strongly, inspired by Krueger and Engerlbart's works. The first platform presented is *Tangible Tiles* (Waldner et al., 2006): in this interface the digital images are projected on a surface. By placing a transparent tile on top of these projections, the underlying image becomes associated with the tile (figure 2.5). System perceives moving, rotating, and flipping of a real tile, which directly invokes the appropriate manipulation of the associated projected data: the illusion suggests that data on the surface becomes "graspable" through the tangible tile. The authors developed three simple games to test the system: results showed some problems and vulnerabilities in utilization that let the interface to be rated more uncomfortable to use than a commercial touch screen. Another important experiment to mention is *EyesWeb* ((Camurri et al., 2004): designed by Camurri et al. at the University of Genova and developed by InfoMus Lab since 1997, it supports various functionalities like object, face and gesture recognition and motion tracking. By exploiting signal processing, *EyesWeb* Motion Analysis Library extracts expressive features from human full-body movement, quantity of motion and contraction indexes. These features were employed in applications like *Orchestra Explorer*, where users can explore the various instruments and sounds from an orchestra through movement (Camurri et al., 2007). Nowadays, interactive spaces and *EyesWeb* are part of the EU ICT H2020 project DANCE *Dancing in The Dark* (Project N. 645553) devoted to the development of "techniques and models for human body movement quality analysis, with a focus on the expressive component of nonverbal communication and on mapping of such qualities onto sound and music generation and processing"
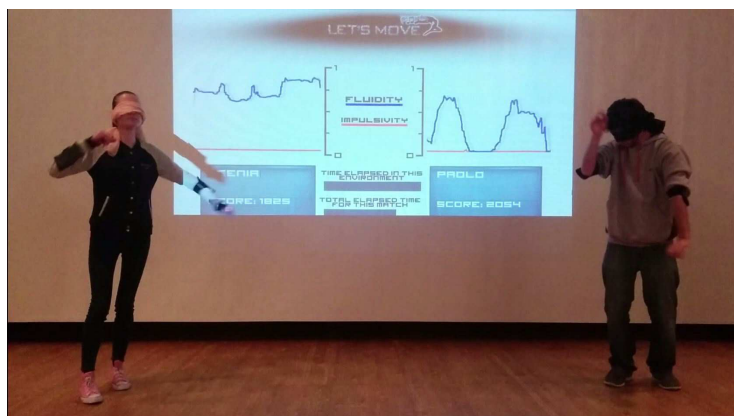
Figure 2.6: *Two players in a Move In the Dark session.*

(Kolykhalova et al., 2016). One of the first works realized within this project is the *Move In the Dark* application (Kolykhalova et al., 2016): two users, each one equipped with two smartphones attached to the arms with an armband, perform a game in three step. At the beginning of the game two players should write their names and how long they want to play (1, 2 or 3 minutes), then the system starts to produce the first sonification of one of the available movement styles (fluid, rigid and impulsive). Each player is asked to move with one of these movement styles and, finally, a score show who have been the ablest to correctly translate the sonifications into features (Figure 2.6). Another experience presented here is *Wizefloor* (figure 2.7), an academic project that turned into a commercial product [10]. It was originally developed by Leong and Iversen (Leong and Iversen, 2015) at the Interactive Spaces Research Centre and based on the previous work on iFloor and iGameFloor (Grønbæk et al., 2007). *Wizefloor* system provides an interactive area of 2x3 meters where multiple users are tracked using a camera system: the system have been proved to be able to work under every light condition except direct sunlight. Users download the chosen game from a dedicated server and can record the game's results for group competition or teacher assessment: so the platform comes also with a system of basic gaming context for a deeper exploitation. The platform is equipped with a variety of games, as reported in (Mandanici, 2016) *SMALLab* (Situated Multimedia Art Learning Lab) [11] is another commercial initiative born from an academic project from (Birchfield et al., 2006) at the University of Arizona. The system is equipped with motion-capture cameras, short-throw projectors and wireless controllers to immerse players in dynamic game-based scenarios, where they can interact in a shared physical space. Also *SMALLab* comes with a great variety of applications, resumed by Mandanici in (Mandanici, 2016). Birchfield et al. (Birchfield and Megowan-Romanowicz, 2009) described in depth an experiment of *SMALLab* utilization with an interactive application for geology concepts dissemination. Results coming from experiments over 72 test subjects revealed how mixed-reality technologies can offer a number of advantages over other tools for collaborative learning, which, on the other hand, must be used in the context of well-designed

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[10]https://www.wizefloor.com/
[11]http://smallablearning.com/

Game	Aim	Interaction modality	Typology
Floor menu	selection	step	information display
Quiz	answer yes or no	step	challenge
Stepstone	quiz solution	step	challenge
Stepstone Ling Game	quiz solution	step	therapy
Balloons	choose the symbols	step	inquiry learning
Floor keyboard	symbols ordering	step combination	challenge
Theme cards	card-map connection	step	inquiry learning
Geometrix	creation of geometric forms	step or object positioning	inquiry learning
Memory	place-content connection	step combination	memory game
Flowers	walk	walk and step	sensory game
Poll	answer	step	information display
Scratch	remove scratch layer	step	sensory game
Football	kick the ball	walk or run	real game reproduction
Paper lines	conceptual connections	step combination	challenge
Slides	content management	step	information display
Pong	moving the bat	walk or run	real game reproduction
Rubber ducks	make ducks squeak	step	sensory game
Piano	select a key and see the notation	step	inquiry game
Bubbles	make bubbles burst	step	sensory game
Categorize	conceptual connections	step	challenge

Table 2.1: *Table of Wizefloor and, previously, iGameFloor/iFloor apps. Aim, interaction modality and typology are reported for each game.*

Game	Aim	Interaction modality	Typology
Character profile	select personal information	wand head, heart, feet	information display
Chemistry Titration	put elements in the flask	wand drag and drop	inquiry learning
Color Mixer	mixing RGB components	wand head, heart, fee	challenge
Constant Velocity	moving along abstract representation	keyboard or remote controller moving wand	inquiry learning
Constant Acceleration	comparing data with movement	keyboard or remote controller moving wand	inquiry learning
Disease Transmission	experiment various transmission models	remote controller and wand drop and drag	inquiry learning
Fraction Lab	moving along abstract representations	keyboard or remote controller moving hands (kinect)	inquiry learning
Fraction Action	using data in a timed scenario	keyboard or remote controller moving hands (kinect)	inquiry learning
Gear Ratio Explorer	generate gears	distance hand-shoulder	play-acting
Gear Ratio	matching movement with gear ratio	distance hand-shoulder distance	play-acting
Geology Layer Cake	matching objects earthquake generation	wand drag and drop shake handheld devices	inquiry learning
Le Tour de Force	matching movement with strength	spinning arms	play-acting
Lever Fulcrum Explorer	mechanics concepts manipulation	arms and shoulders	play-acting
Lifting Gears	mechanics concepts manipulation	spinning arms	play-acting
Light and Mirrors	element manipulation	wand drag and drop	inquiry learning
Lightwave	wavelength-color relationship manipulation	wand drag and drop	inquiry learning
Memory	place-content connection	wand drag and drop	challenge
Oscillating Spring Mass	physics parameters manipulation	wand movement	inquiry learning
Order Line	ordering symbols		challenge
Particle Predator	rule decision	wand drag and drop	challenge
Projectile Flight Game	rule decision	wand movement	challenge
Projectile Flight Graph	strike a virtual ball	wand movement	inquiry learning
Red Rover	catch and crush		challenge
Storyline	image and sound creation		inquiry learning
Sunshine Hearth	orbital position manipulation	wand movement	inquiry learning
Traffic Jack	lift level	arm length	play-acting
Venn Diagrammer	conceptual connections		challenge
Word Play	quiz solution		challenge

Table 2.2: *Table of SMALLab applications.*

Figure 2.7: *Pupils using WizeFloor technology.*

learning scenarios and teaching practices. In other words, the experience must be organized and designed in order to not include factors that could interfere or disturb the primary educative goal. *AmI Playfield* is a project started in 2009 within the framework of the AmI (Ambient Intelligence) Programme at the Foundation of Research and Technology, Hellas - FORTH in Heraklion (Crete). The project is focused into creating experimental AmI spaces for art and culture, commerce, healthcare, home, learning, education and workplaces to promote entertainment and learning, by enhancing physical play and combining location awareness through multimodality. It consists in a 4x4 m^2 area partitioned in a grid of gaming positions through plastic stripes, with parallel dual back-projection display, an information kiosk used to host a remote game manager, a collection of smartphones used as additional game controllers and of a surround speaker system (Papagiannakis et al., 2013). It was assessed using the *Apple hunt* game (see Figure 2.8: a serious game devoted to the training of arithmetic capabilities. Results showed that fun, including expressions of joy and laughter, were enhanced by all participants' spontaneous will to continue playing at the end of the sessions, while negative expressions or boredom were not observed. Learning the game did not pose difficulties to the participants, whereas all participants experienced full engagement in the game. Another project that exploits potentialities coming from these technologies is *Learning Physics through Play Project* (LPP): it is based on the idea that young children can, under the right circumstances, learn more complicated ideas than we currently ask them during early elementary science education. They can engage in productive inquiry, collect and analyse data, produce models, and learn complex concepts (Enyedy et al., 2012). The system was employed to disseminate notions about Newtonian force and motion. The system consists of a 3.5x3.5 meters carpet with a whiteboard for LPP microworld projection and a users tracking system (check Figure 2.9). Assessments' findings suggest that many of the students made significant progress in learning, as measured by the pre-and post-test. The system then evolved into STEP (Science through Technology Enhanced Play), realized with utilization of *OpenPTrack* framework (that will be detailed later) and tested, with encouraging results, in an application devoted to disseminate knowledge about state of matter.

Figure 2.8: *A girl playing Apple Hunt.*
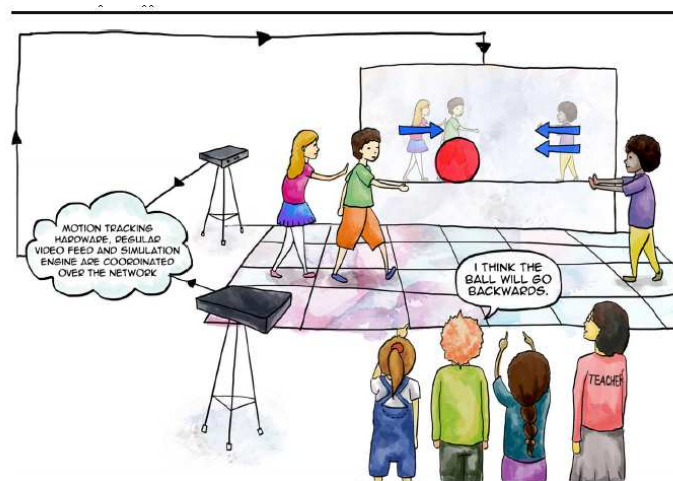
Figure 2.9: *LPP Architecture and Example.*

2.3   Integrated gaming services and platforms

The idea behind this work comes from the observation of the actual entertainment videogames market, focusing, in particular, on the possibility to enhance players' experiences in serious gaming in the same way the commercial entertainment industry does since more than a decade. Modern platforms and services, in fact, interact and entertain players in a completely different way, compared to the past. Karppi, in chapter 4 of "*Games as Services - final report*" (Sotamaa and Karppi, 2010), recalls that, historically, video game consoles used to be pretty close systems: they were basically devices with a very essential Operating System, just linked to a monitor (typically a domestic TV system). Games used to be sold in physical copies (in the earliest times using cartridges, then replaced by optical supports) and gaming experience was limited within the domestic system, eventually shared just with people physically attending or participating the session. This kind of system have been defined also by Chang as "Gaming 1.0" (Chang, 2010), also because they featured a distribution model strongly based on traditional retail channels. The only exception to this model was represented by the videogames market on personal computers: the versatility and malleability of this platform let the industry to develop games with more features (like the exploitation of early internet connections), but still linked to retailers and physical supports (It would have been irrational to expect users to download even hundreds of Megabytes and keep the devices permanently connected). The advent of cheap broadband internet connection started to break this closed paradigm, where networking was considered, up to this moment, as an exclusive prerogative of personal computers, due to the scarce massive internet connection availability, reduced bandwidths and dial-up connections fares and limitations. The sixth generation of consoles (started with the launch of Sega's *Dreamcast* in 1999) was the fist trying to fill this gap and deal with a network-oriented paradigm: these systems were equipped with a network interface, letting users play online multiplayer sessions gaming sessions with the (few) games who allowed that. In 2002 Microsoft launched the very first version of its gaming services platform, called *Xbox Live* (Figure 2.10): the service mainly served as a multiplayer-enhancement service and it was the first to implement basic social dynamics, like persistent links among players ("friendships") and the possibility to chat via text or VoIP in one-on-one and group conversations. This kind of services were not an absolute novelty: in fact, gaming communities for PC gamers started to rise in the 90s (the most famous was *GameSpy*, founded in 1999 [12]). Services provided by these communities were: help players to meet and organize multiplayer sessions, organize temporary or persistent teams ("clans"), provide IPs and ratings of servers dedicated to gaming and boost the distribution of game updates (official and unofficial) and modifications created by passionate users (the so-called "game mods" or simply "mods"). However, *Xbox Live* was the first to bring such mechanism with such social interaction models in the domestic console world, being the first to perform it at a professional level: indeed, the service was not free and required a subscription fee. It is interesting to notice that this platform was launched more than two years before the massive spread of the social networking paradigm: social networks existed already (the first one, dated 1997, was *SixDegrees* [13]), but they were small

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[12] https://en.wikipedia.org/wiki/GameSpy
[13] https://en.wikipedia.org/wiki/SixDegrees.com

Figure 2.10: *The first Xbox Live screen on the Xbox home system.*

realities of very small dimensions, far away from the actual size of social networks (*Facebook* foundation is dated 2004 and its worldwide success took place three years later [14]). A big boost to this technology was given again by Microsoft, with the release of the *Xbox 360* game system (dated march 2005), who came up with a totally renewed version of its *Xbox Live* service, turning into something that could be called "integrated gaming services platform" or "gaming context network". This fact marked an historical milestone in the history of videogames market, by opening it to the paradigm of a gaming system definitively connected to the world: the new connected system "lives" and releases its full potential when connected to internet, letting player to expand its experience. In fact, besides the "traditional" form of in-game multiplayer competition and the confirmation of social mechanisms for gamers, these new services let the players to:

- show to the rest of the world their overall playing activity and measure it by using a brand new achievement system;

- test, buy and rate games and add-ons from a dedicated marketplace;

- create personal profiles enhanced with 3D customizable avatars (actual *Xbox Live* profile page is in Figure 2.11);

- establish links and social relationships with other players;

- share and publish his/her own performances (images or footages);

- publish their own games and discover products made by independent developers;

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[14]https://en.wikipedia.org/wiki/Facebook
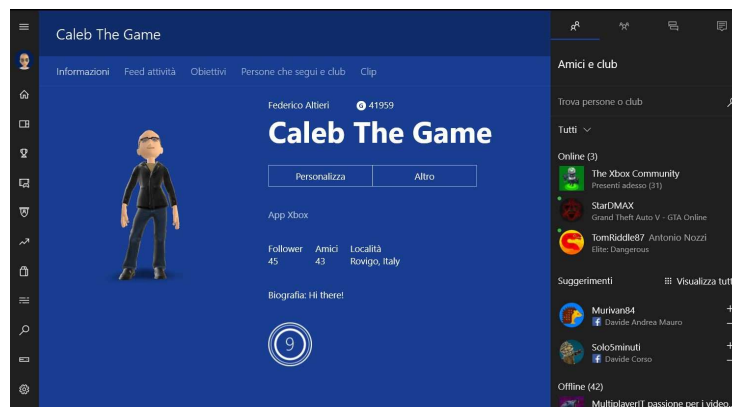
Figure 2.11: *The actual Xbox Live profile page on the Xbox One home system.*

- join other media delivery content services from external providers (e.g. *Netflix*).

The switch of paradigm was clear: from being an autonomous, but isolated, closed and limited system, to being a complete media center for home entertainment, connected to the world, where it gives its best. With this huge improvement, Microsoft marked a successful milestone that could not have been ignored by the concurrency. In fact, one year later Sony launched its brand new *Playstation Network* [15] platform, who tried to fill the gap with the rival, while in 2007 Valve introduced such mechanisms in its *Steam* platform[16], transforming it from a simple digital delivery videogames retailer into a proper gaming services platform for PC players.

2.3.1 Achievement systems

The achievement system was one of the most acclaimed and revolutionary novelties introduced by Microsoft with *Xbox 360* release. Sotamaa, in chapter 6 of "*Games as Services - final report*" (Sotamaa and Karppi, 2010), recalls and tracks how this came out as a little revolution for the players. Achievement systems are secondary reward systems that have been developed for digital games: a player can complete optional sub-goals to earn achievements' rewards (points or virtual trophies), visible to other players (Montola et al., 2009). Moreover, these achievements are not limited to single games, because all the achievements unlocked (by playing all the games on a certain platform) concur to a global personal amount that could be used to compare the overall player performance (Figure 2.12). These aspects became a vital part of the experience and they have been recognized by both Montola and Sotamaa as a source of motivation for the players to keep playing the game. Players are stimulated to explore games deeper and, sometimes, to perform tasks that they would not do otherwise. So, if observed from the developer's point of view, achievements are a great instrument to maintain high the player's interest and to stimulate gaming style adaptation and evolution. However, Montola in (Montola et al., 2009) also pointed out that achievements could be a good catalyst, but just in case of an already existing good user

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[15]https://en.wikipedia.org/wiki/PlayStation_Network
[16]https://en.wikipedia.org/wiki/Steam_(software)
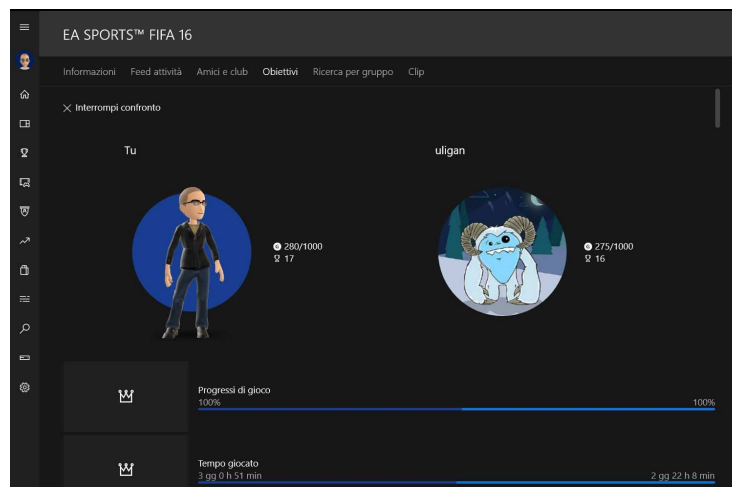
Figure 2.12: *View of the achievement comparison with other people in the Xbox Live environment.*

experience. It was showed that, in case of an experience which is not satisfactory or somehow attractive, an achievement system is not able to "save the day" and turn a non-engaging user experience into an engaging one. Moreover, achievement unlocking must be explicit to the user (in game alerts, pop-ups or other alerting mechanisms), in order to be properly exploited. After an accurate observation of opinions and behaviours of the players, relatively to the introduction of achievements systems, Jakobsson (Jakobsson, 2011) stated that they started acting like they were immersed in a new *MMO* (Massivey Multiplayer Online game). This fact led to both positive and negative facts: among the positive facts, it could be recorded the above-mentioned stimulus to keep playing the games and explore them from different point of views, in order to unlock as more achievement as possible; on the other hand we can assist to phenomenons of player awareness for result comparing, with cheats and the rise of a market where people sell high ranked accounts for real money or services that claim to provide immediate achievement unlocking (a phenomenon very similar to the "gold farming", a very common (and blamed) practice in *MMORPGs* like World of Warcraft [17]).

2.4 Summary

The outcomes from the literature review and the observation of reality can be, in the end, resumed in the following points:

- Commercial serious games field, except few successful products (e.g. the *Carmen Sandiego* franchise, recent experiment of *Minecraft Education Edition*) failed to hit the scene, due to problems on the producers' approach: the focus on the educative aspect of the experience let them forget about the need of the product to be entertaining also. In other cases,

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[17]https://en.wikipedia.org/wiki/Gold_farming

poor productions processes produced products with good ideas, but limited in terms of technology.

- Academic literature provides a huge load of works on serious games: some important outcomes evidenced the need of feedback system, to let user to learn from their own mistakes efficiently. Users tend to reward and get involved by even minimal gaming context mechanisms (like simple score rankings).

- The academic approach on the serious games research provides products which are far away from videogames commercial standards in terms of gaming services and contexts, often resulting in "isolated" experience in space and time (they happen just where and when the experiments are run).

- Commercial integrated gaming services defined, since more 10 years, a de-facto standard on the topic of the gaming context where the videogames are placed. Player communities, achievement systems and marketplaces are considered by players as a fundamental, thus expected, part of their gaming experience.

- There is a general lack of attention on the long run dimension of these technologies, both in modelling a new educative experience that could become a part of the scholastic lifetime and in evaluating impact of these instruments over long periods (like a full year).

Chapter 3

Serious games research at the SMC group ad DEI, Unipd

Experience carried on at the Sound and Music Computing Laboratories of the Department of Information Engineering of the University of Padova, started with the work of Zanolla et al (Zanolla et al., 2013) with the *Stanza Logomotoria* project, that then evolved into "AiLearn" and continued its development with Mandanici's works (Mandanici et al., 2015). *Stanza Logomotoria* presented an interactive space with a webcam-based tracking system, with applications like *Fiaba Magica*, devoted to the stimulation and the phonetic empowerment of pupils with severe disabilities. Mandanici took the Zanolla's legacy and let the system evolve into the *AiLearn* project: differently from *Stanza Logomotoria*, *AiLearn*'s people tracking is realized thanks to the *OpenPtrack* framework developed by Muraro, Menegatti et al from the Robotics Lab of the Department of Information Engineering of the University of Padova (Munaro et al., 2014) (Munaro and Menegatti, 2014). Mandanici presented and tested some applications devoted to music composition and teaching: the first one was *Jazz Improvisation*. *Jazz Improvisation* is an entertainment listening application based on composition techniques employed in jazz and in many other popular music genres. Musicians start from a shared musical mode (which provides a pool of available notes) and from a common musical meter. They improvise their instrumental musical patterns and combine this material in various ways. As the patterns can be freely superimposed, the application's surface is subdivided into nine zones without any particular element relationship (see figure 3.2). When a zone is occupied for the first time, the music pattern is played, but, if the user returns on the same zone, the corresponding audio file is muted. This creates a dynamic relationship between the user's path and the composition state, which changes every time the user moves.

3.1 Harmonic Walk

Harmonic Walk (HW) was designed to be an application devoted to the study and practice of western tonal harmony. This application was the major subject of Mandanici's work at the SMC group at DEI, UNIPD and was described and discussed inside her final Ph. D. thesis (Mandanici,

Figure 3.1: *A girl playing the Good or Bad? during the 2015 European Night of the research, at the Palazzo del Bo in Padua.*
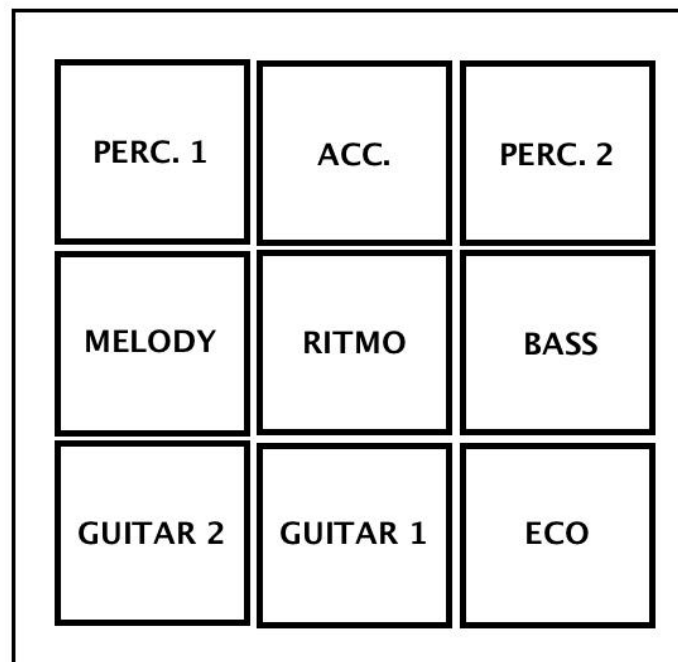
Figure 3.2: *Jazz Improvisation's floor partition scheme.*
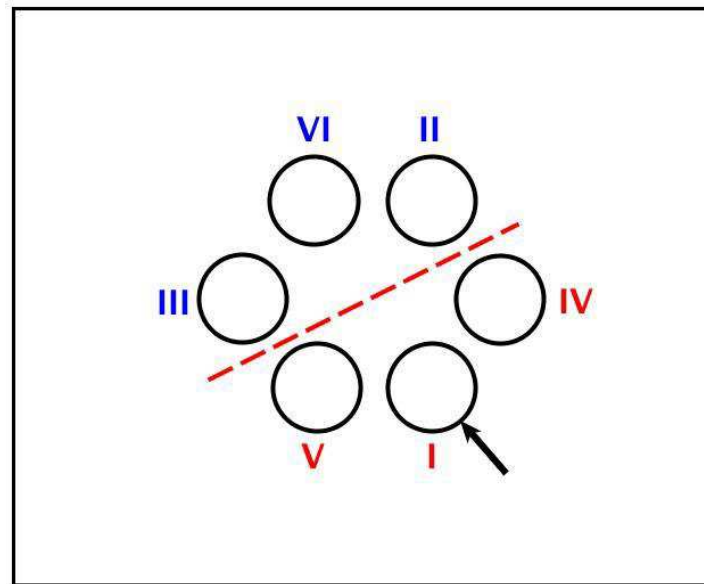
Figure 3.3: *Representation of chosen Tonnetz' section on the Harmonic Walk application.*

2016). The theoretical base upon the application relies on the concept of spatial representation of the harmony space, in particular a bi-dimensional surface. This exploits the concept of "tonnetz", literally "web of tones", introduced for the first time by Euler in 1739 and then revised and upgraded by the German music theorist Hugo Riemann during the 19th century. In HW, a major tonality harmonic space taken from the tonnetz is projected (theoretic tonnetz is a three-dimensional graph) on the application's floor where chords are represented by circles. According to the tonnetz' spatial relationships, the fundamental roots are disposed one after the other with the tonic chord in the middle and the V and IV degree at the sides. In front of the fundamental roots, there are the three parallel roots, like in figure 3.3.

Application functioning is very simple: when a user walks into a circle, the relative chord is played through the system's speakers. This means that HW is a *de facto* simplified musical instrument that requires no technical skills in order to be used and played. Mandanici's ambition was to employ this technology in order to understand how abstract knowledge could be disseminated through a spatial representation. Results showed that even complex musical concepts, like "harmony" and "harmonic space", could efficiently "reach also untrained users and allow them to accomplish complex tasks like 'melody harmonization'. A certain amount of musical knowledge and awareness of the employed musical concepts is achieved by test subjects, also if no additional musical information is provided." (Mandanici, 2016). Another important result achieved by Mandanici was about access method, stating that "if the same task has to be performed on an active floor and on a touch screen surface, users prefer the latter and perform better in the touch modality than in the full-body".

3.2   Good or Bad?

Good or Bad? (GoB) is a two players game devoted to musical listening and music layer's discrimination (figure 3.1). "Good or Bad?" game can be ascribed within works of three main reference research fields: video music games, responsive floors environments and active music listening applications. Theoretic framework is based on the concept that a non-monophonic piece of music can be seen as the superposition of different musical layers, corresponding to various instrumental parts (strings, basses, percussion, keyboards, etc.). In this serious game, the users have to rebuild a certain music piece, whose tracks have been mixed with those from another piece from the same repertoire. The game is thought to be a 2 players collaborative game, each one moving in a half of the projected floor's space: while a player unfolds the tracks by jumping over them one by one, the other has to choose if the just unfolded track belongs to the song to rebuild or not. Tracks unfolded are reproduced in loop by AiLearn's speakers, giving the time to the players to think, talk each other and come to a common decision. Two groups of musical layers (represented with stars and squares), belonging to two different compositions of the same genre (classical, pop, etc.) are used. The musical layers are placed in eight positions on the surface reserved to the first player, while the second has to jump on the *Good* or *Bad* area to answer to the question posed by the game. Only after the identification of four compatible layers the system will perform the complete composition and the game is won: on the opposite, with three errors, the game is lost (Figure 3.1). Tracks unfolded belonging to the song to rebuild are kept constantly played for all the game.

3.2.1   The "Good or Bad?" Game Workflow

The game's workflow is resumed in Figure 3.4.

The game is played by two players who start standing close to the responsive floor area. At the beginning of the game, the players choose one of the three music repertoires depicted in the projected image of Figure 3.5. By walking on the corresponding zone, one of the users can play some samples and, then, can select one of them by stepping on the number of the chosen repertoire (Repertoire selection).

When the decision is made, the playing area appears on the floor surface: it is divided in two halves by a black line, each one reserved to one of the two players, referred here as "Player A" and "Player B" (see Figure 3.6).

Player A has to walk inside circles on the left side of the game area: by doing this, he enables the playback of the first track of what will become the "reference piece" (first track selection). Here, the players have 10 seconds just to listen to the just unfolded first track, that will be the base to reconstruct the reference piece. After that, on the left side, a series of blank circles appear, inviting player A to walk on one of them. This action unfolds a new track, that is played at louder volume on the right channel. "Good?" and "Bad?" buttons appear on the right side of the responsive floor, inviting player B to decide if the just unfolded track belongs or not to the reference piece. Answer is processed according to its correctness: if the answer is wrong, a life is lost. Then, if the track belonged to the reference piece, it is overlapped to the other tracks already unfolded, otherwise it is muted and discarded. Players win if they manage to unlock all
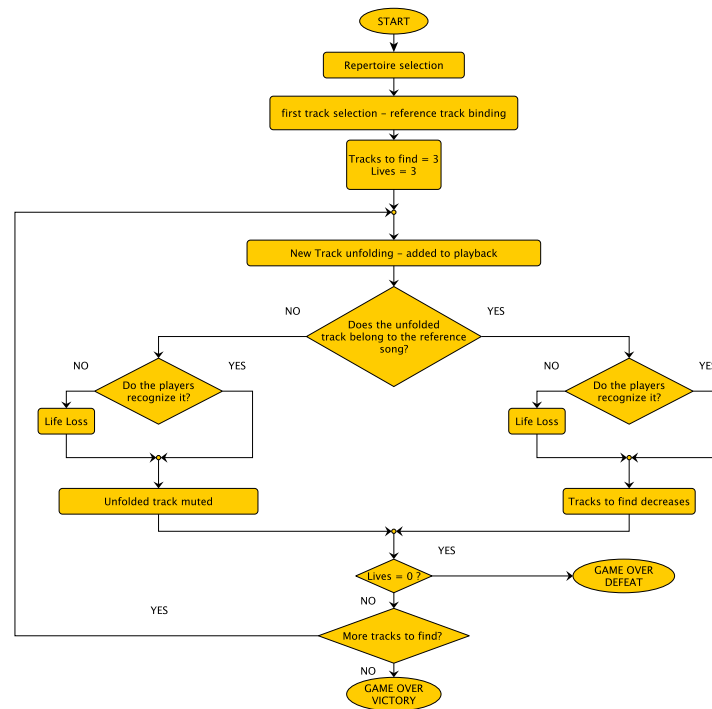
Figure 3.4: *The Good or Bad? game flowchart.*

Figure 3.5: *GoB repertoire choice screen.*
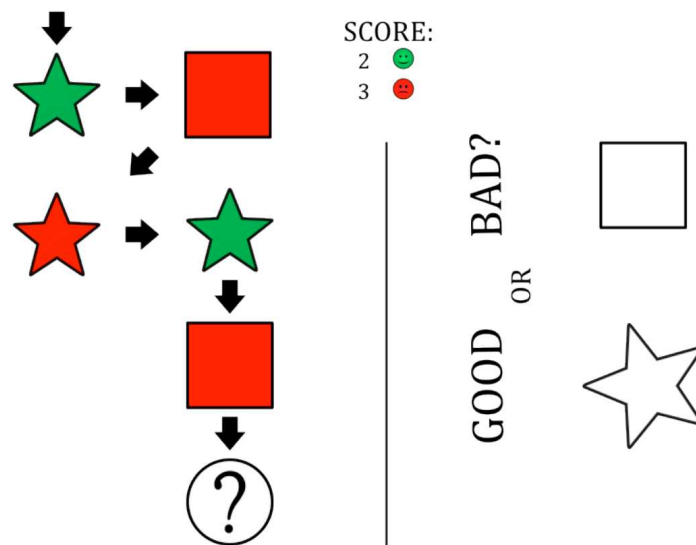
Figure 3.6: *The projection of the playing area of the Good or Bad? game.*

the 4 tracks of the reference song without losing all the 3 lives given them at the beginning of the match, otherwise they lose the game.

3.2.2   Assessment

GoB game was evaluated in within two different experimental scenarios: during a public exhibition and by means of a controlled experiment carried out in laboratory. The first experiment was mainly to evaluate the software reliability in a non controlled environment and, in the same time, to have a first look about audience's reception. The second experiment was oriented to evaluate if and how the game produces changes in the users' active listening skill and if user interfaces are related to these changes and/or the engagement level.

3.2.2.1   First scenario: public exhibition

The application was deployed and set up during the European Researchers' Night [1] at the Palazzo del Bo, Padova. Access to the installation was open to everybody without any restriction. The system was kept on for 7 hours without any restart or reconfiguration, thus showing good software reliability even in a very crowded and chaotic situation. In total, we had 150 people involved and 120 matches played. More than 60% of the users asked to play more than one match and among them about 30% tried to play with all the 3 repertoires. However, only 99 out of 120 matches were completed, because some users abandoned the match session before the end: mainly they were very young children who enjoyed the interactive graphics but who could not be aware about the gameplay and the required task. All data about played games are resumed in Table 3.1 and in a portion of 3.3. Repertoires were:

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[1] http://ec.europa.eu/research/mariecurieactions/about/researchers-night_en

Music Rep.	Duration of Repertoire Song Excerpts (s)	Match Lenght (s)		Turn Lenght (s)	
	Mean	Mean	St. Dev.	Mean	St. Dev.
Battisti	33.5	140	43	15	6
Abba	37	138	54	15	7
Vivaldi	40	133	37	14	6
TOTAL	36.83	137	45	15	6

Table 3.1: *Statistical data for the average duration of the two song excerpts belonging to the same repertoire, of the match and single turn lengths.*

- Italian popular music, including two songs of the Italian songwriter Lucio Battisti[2], *Acqua Azzurra* (1970) and *Fiori rosa fiori di pesco* (1970);

- international popular music, including two songs of the Swedish group Abba,[3] *Dancing Queen* (1976) and *Mamma Mia* (1975);

- classical baroque music, including two classical pieces taken from Antonio Vivaldi's *Le quattro Stagioni* (1723)[4], Concerto No. 1 in E major, Op. 8, RV 269, *La primavera* Allegro (in E major) and Concerto No. 4 in F minor, Op. 8, RV 297, *L'inverno* Largo (in E-flat major).

Games were equally distributed over the three repertoires, with an average of 65.5% of overall successful matches. The chi-square statistic reports no significant difference of victories and defeats among the 3 repertoires, as showed in Table 3.3. Table 3.1 shows also similarities in match and turn durations. A "turn" is intended as the time spent by users to hear tracks in playback and evaluate if they belong to the same song or not: data showed that the average turn duration is similar for every repertoire and it is rather short compared to the average duration of the song excerpts. This means that, in general, users' behaviour tends to be indifferent to the music repertoire, while, on the other hand, even within the the same repertoire, not all the track combinations have the same ratio of wins and defeats, as reported by Altieri et al. (2016), i.e. some combinations results to be more difficult to guess than others. These statistics have been employed to determine the less successful game combinations of tracks unfolding, which will be useful to determine the experimental game set described in the next Section.

3.2.2.2 The controlled experiment

After this experience, a controlled experimental setup was designed: subjects were asked to play three matches of GoB under two different experimental conditions: one, named RF, with AiLearn

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[2]See http://www.luciobattisti.info for Lucio Battisti's reference.
[3]See http://www.abbasite.com for Abba's reference.
[4]See xhttps://en.wikipedia.org/wiki/The_Four_Seasons_(Vivaldi) for *Le quattro Stagioni* reference.

interface; the other, named TS, reproduces the same game (graphics, sounds, game logic), on a device with a touch-screen input. To verify if the game can improve users' listening skills, it was built an ad-hoc listening test: the test replicates on a desktop computer the discriminative task that is the basis of the game, the recognize of the belonging of a series of tracks to same piece. The listening test was proposed both before (pre-test session) and after (post-test session) GoB utilization. Finally, the user's engagement was measured by administering to subjects a questionnaire at the end of the post-test.

60 subjects chosen mainly among university students and researchers (age $mean = 25.1$ $sd = 5.7$ years, 27 females and 33 males) were invited to take part in the experiment. AiLearn and the 25 inches touch screen used for testing were installed in a quiet room of 6x8 meters, with reverberation time $RT_{60} = 0.6s$. Subjects were randomly assigned to one of the two experimental groups, named RF (responsive floor) and TS (touch-screen). Two different sets of musical tracks were employed in the experiment. The first set, named the Game Set, was composed by the tracks used during public exhibition (that subjects did not attend); the other, named the Test Set, was built on the same schema, but with different music tracks:

- Italian pop songs were *Buonanotte Fiorellino* (1975) and *Generale* (1978) by the songwriter Francesco De Gregori[5];

- international pop songs were two songs by the Abba, *Money, money, money* (1976) and *SOS* (1975);

- classical baroque compositions are Tommaso Albinoni's *Adagio* in G minor and Arcangelo Corelli's *Adagio* from the Recorder Sonata op. 5 (1700).

The **Game Set** was used for the GoB matches. As evidenced in Altieri et al. (2016), not all the track unfolding sequences have the same ratio of wins and defeats, due to the musical characteristics of the various combinations. Thus, author built a really challenging Game Set, employing the less successful game combinations of tracks unfolding. The **Test Set** was employed to build a listening test aimed at evaluating the subject's active listening skills before and after playing the game (pre- and post-test). The listening test was composed by 18 trials, chosen calculating the mean of comparisons per match (min 4, max 8), multiplied with the number of matches played by the subjects (6*3 = 18). The musical tracks belonging to the Test Set repertoires are employed in the following way: 6 trials feature a comparison of 1 with 1 track; 6 trials featured a comparison of 1 with 2 tracks; 6 trials featured comparison of 3 against 1 track and each of these subgroups featured 3 correct and 3 incorrect comparisons. This aims to be a representation of the possible game cases, where the user has to compare the various tracks with a growing number of overlapped tracks as the selection proceeds. Finally, the questionnaire employed for the measurement of engagement is an adapted version of the GEQ (Game Engagement Questionnaire) by Chen et al. Chen et al. (2005) and already employed in other studies on user engagement (Bianchi-Berthouze, 2013; Moreno et al., 2015). As the original GEQ, this version focuses on 4 fundamental aspects of engagement: gameplay (P, 5 questions), enjoyment (E, 4 questions), immersion (I, 2 questions) and game elements evaluation (G, 3 questions). The answers to the

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[5]See `http://www.francescodegregori.net/fotFrancescoDeGregori`'sreference

Figure 3.7: *The computer screen graphical interface for the Good or Bad? pre- and post-test.*

questionnaire were recorded in form of a 10-values Likert scale, where value 1 is "disagree", while 10 is "totally agree". The overall 14 questions are presented in Table 3.5.

Participants to the experiment underwent the test singularly. Each one received a brief description of task required, and was put in the room with the interactive installation. During experiments, only the test subject and a test supervisor were present in the room. The experiments consisted of the following four phases:

1. **Pre-test.** The aim of this phase is to measure subject's active listening skill before playing. It consisted in a set of trials that reproduced the in-game comparisons. The tracks, as well as the various combinations, are randomly chosen by the system, with the only constraint that the overlapped tracks must belong all to the same composition (the "reference" piece). The trials were submitted using a headphone audio system Beyerdynamic DT 770NM and a graphical interface (Figure 3.7). The overlapped reference tracks were played on the left headphone channel. After 15 seconds, the track to be evaluated was played in the right channel (together with the tracks on the left channel) for a maximum time of 90 seconds (approximately three times the duration of single audio segments). If the test subject does not respond within this time lapse, the answer is considered as "not given".

2. **Playing the game.** Subjects were asked to play 3 GoB scripted matches, one for each available game repertoires. Each match featured 6 unfolded tracks with a total of 15 comparisons, 5 for each match. In each match, 3 unfolded tracks belonged to the reference piece, while 2 did not. In this phase, one half of the subjects (the "RF" group) played with AiLearn's responsive floors, the other (the "TS" group) played with a touch-screen interface, reproducing the same floor projection depicted in Figure 3.6.

3. **Post-test.** It worked under the same conditions as pre-test, but with different comparisons. The goal was to evaluate is the game changed somehow the music active listening skill of the test subjects.

Correct Answers (%)	RF+TS		RF		TS	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
Mean	78.90	79.91	77.04	77.96	80.56	81.85
St. Dev.	11.64	11.11	13.27	12.92	9.65	8.74
t-value	-0.53		-0.38		-0.93	
p-value	0.59		0.70		0.35	

Table 3.2: *Averages of correct answers in the pre- and post- test phases.*
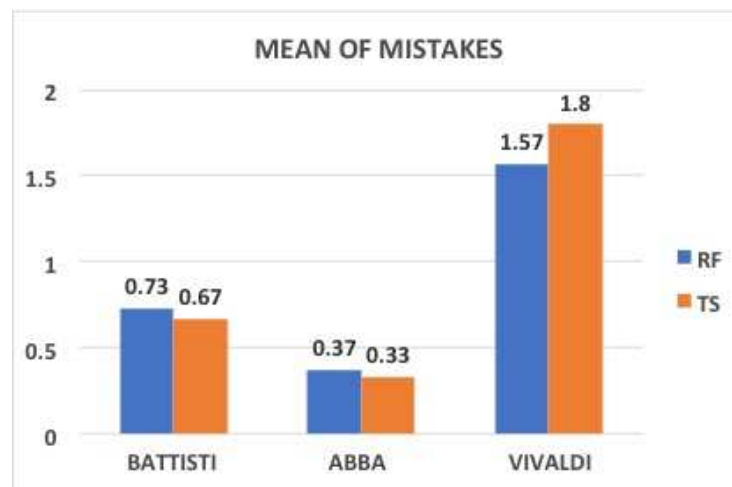
Figure 3.8: *Mean of mistakes recorded on the gaming phase under the RF and TS condition.*

4. **Engagement evaluation.** At the end of the test, the questionnaire for the engagement evaluation was fulfilled by the subjects.

3.2.2.3 Results

To evaluate the impact of GoB on the active listening skill, we collected and compared answers coming from the pre- and post-test phases. Table 3.2 reports the average of correct answers for the RF and the TS group. A small increase of correct answers' percentage was observed in both the groups, but not in a statistically significant way. Therefore, under these conditions, the game does not significantly affect users' ability in answering correctly to the trials. During the gaming phase of the controlled experiment, subjects had a greater victory ratio than audience of the public exhibition. Moreover, while the responses collected during the public experience did not show any significant difference among the available repertoires, during the controlled experiment there was a significant difference ($\chi^2(1, N=30)$ 12.21, $p < .01$). This difference is particularly important with classical music repertoire, as confirmed by the number of mistakes reported in Figure 3.8. The other aspect this research aims to assess is how different interfaces could have a different role in gaming and learning experience It was noticed that, during gaming phase, that subjects showed major difficulties to answer than audience in the public exhibition. As reported in Table 3.4 the overall number of victories/defeats is better in the RF than in the TS

Music Rep.	Researcher's Night			Controlled Experiment**		
	Matches	Victories	Defeats	Matches	Victories	Defeats
Battisti	31	22 (74%)	9 (26%)	60	57 (95%)	3 (5%)
Abba	37	23 (62%)	14 (38%)	60	59 (98%)	1 (2%)
Vivaldi	31	20 (64.5%)	11 (35.5%)	60	49 (81%)	11 (19%)
TOTAL	99	65 (65.5%)	34 (34.5%)	180	175 (97%)	15 (3%)
** significant at $p < .05$						

Table 3.3: *Resume of all data collected in both experimental scenarios*

Music Rep.	RF		TS**	
	Victories	Defeats	Victories	Defeats
Battisti	29 (97%)	1 (3%)	28 (93%)	2 (7%)
Abba	30 (100%)	0 (0%)	29 (97%)	1 (3%)
Vivaldi	27 (91%)	3 (9%)	22 (73%)	8 (27%)
TOTAL***	86 (96%)	4 (4%)	79 (88%)	11 (12%)
*** significant at $p < .10$, ** significant at $p < .05$				

Table 3.4: *Details of matches statistics for both experimental conditions scenarios subdivided into the 3 different repertoires*

condition ($\chi^2(1, N=90)$ 3.56, $p < .10$), with a p-value .059, very close to the threshold of .05. A further analysis about performances under TS condition revealed an overall significant difference ($\chi^2(1, N=90)$ 8.09, $p < .05$). Subjects who played in the RF condition looked to manage better encountered difficulties, respect to TS condition.

The other aspect of the experience we wanted to address is engagement.

Table 3.5 reports statistics about answers collected with engagement measurement questionnaire. Answers collected on the 14 items show a good or acceptable internal reliability both for RF (Cronbach's $\alpha = 0.81$) and TS (Cronbach's $\alpha = 0.74$), implying that all the items of our questionnaire, measured the same construct, which was the engagement level.

Averages calculated on all 14 items revealed that subjects evaluated as more engaging the RF version of GoB, with a score of 8.57, in comparison to the TS version, who had a rating of 8.15. However, according to t-test, this difference is not statistically significant ($t(56.785) = 1.93$, $p = 0.058$), with a medium effect size (Cohen's $d = 0.50$). In details, RF obtained a higher rate in all items but one: item I1 had the greatest and the only single-item statistically significant difference between RF (9.1) and TS (8.2) ($t(51.026) = 2.292$, $p < .05$). P2r is the only item where RF (6.9) marked a lower score than TS (7.6): this could be due to tracking system's lag, that is sometimes perceivable and could disturb the user. If we do not consider question P2r in analysis, ignoring eventual technical issues, the difference between the average score on the remaining items, under the two different conditions, becomes statistically significant ($t(56.195) = 2.30$, $p < .05$).

		RF		TS	
		Mean	**SD**	**Mean**	**SD**
P1	I was able to understand what would happen in response to my actions	9.4	0.9	9.1	1.3
P2r	I experienced a delay between my actions and game reactions and I found this annoying	6.9	2.7	7.6	2.2
P3	I was able to control the game intuitively and without any ambiguity	9.1	1.1	8.3	2.3
P4	Interface was clear and comprehensible	9.4	1.1	8.7	2.0
P5	It was always clear what it was requested me to do	9.4	0.9	9.2	1.3
E1	I enjoyed myself when playing the game	9.2	1.0	9.0	1.4
E2	I would recommend others to play	9.1	1.0	8.7	1.3
E3	If I could I would like to explore the game deeper	8.5	1.6	7.9	2.4
E4	I would play again	8.8	1.5	8.4	2.1
I1*	I felt involved in the game and within its environment	9.1	1.3	8.2	1.8
I2	I lost time cognition while playing	6.6	2.7	5.9	2.9
G1	I liked the graphics	7.3	2.0	6.8	2.0
G2	I liked music and sound effects	7.9	2.0	7.7	2.4
G3	I liked the game content	9.0	1.3	8.5	1.6

Table 3.5: *Results of engagement measurement questionnaire (* significance threshold at $p \leq 0.05$). The scores to question P2 have been reversed.*

3.2.2.4 Discussion

Tests on impact on the trained skill (active listening) revealed that there was no significant improvement in the post-test performances under both RF and TS condition. Similar studies conducted over longer leaning periods (two weeks) reported that an improvement could be achieved only after a longer exposure to treatment, when the "surprise effect" vanished (Kanda et al., 2004). The first impact effects in the use of a new application (surprise, discovery of the interaction mechanism and playfulness) and delays learning processes. This suggests the necessity to considerate the system on a longer run, in this specific case employing different music repertoires, new involvement strategies (team challenges, tournaments and game levels) and media (web application and mobile applications). About the engagement level, gameplay (P) and enjoyment (E) groups produced the highest means (both at 8.7). Questionnaire revealed that users appreciate the experience and enjoyed the game. Immersion group obtained a lower result (7.4): this is due to question I2 (6.6) poor result, perhaps because this question was not proper for our of game. GoB, in fact, is not a game based on fast reflexes, but rather invites to reflection and thinking. Answers to question I1 are the only one to obtain a significant statistical difference between the RF and TF groups, with a medium effect size. This is important, because it could confirm a real greater involvement power of the RF respect to the TS, confirming the theory of embodied learning (Barsalou, 2008). However, a greater involvement does not lead to an increase of the skill, as confirmed also by similar works (Johnson-Glenberg et al., 2011). So, we are not able to say if this major involvement is an early user's effect or if it persists in the long term and can so be employed to reinforce learning.

3.3 Summary

This chapter contained the experience run at the SMC laboratories about serious games. In SMC labs, the attention was focused on a precise aspect: the definition of the role of full body movement in enactive learning systems, trying to clarify what is its impact and how it affects user's skill training and content reception. Results still failed to give a precise answer to this question, and, in the case of the *Good or Bad?* experience, due to two main limitations: the game seemed to be not adequate to the role and exposure to the treatment period was too short. During this period, the author had the occasion to move his focus from the interfaces to the game itself. In fact these two aspects could not be treated separately, especially when dealing with immersion and engagement. In fact, a good part of the enjoyment coming from such experiences depends also from the quality of overall experience. So, in order to create an attachment of the user to the infrastructure, the gaming experience must be properly designed: this is necessary to let the proposed system to not "lose" the comparison with the actual products provided by commercial market (Anderson, 1973). As stated in chapter 2, serious games' research approach is affected by these two flaws, that cause a waste of the potential usefulness of these instruments in an educative context (like ordinary schools): next chapters of this works, in fact, try to address this problem, trying to define guidelines for a novel interactive learning experience through a pedagogical online network for gaming.

Chapter 4

A new paradigm for technology mediated learning

This chapter will introduce and explain the theoretical guidelines studied in order to answer problems evidenced in review of chapter 2, starting with a decomposition into sub-problems. Then, a strategy to overcome them is presented, proposing a new paradigm of design and development of an interactive educative framework for a new educative experience.

4.1 Serious game isolation and the waste of potential

As explained in the previous chapter, serious games suffer some lacks in the research approach, remaining locked in some kind of "trap". This trap translates into a concrete form of isolation, causing a waste of the intrinsic ability to stimulate the player to keep spending his/her time playing the game. This aspect of videogaming experience have not been precisely focused in precise terms by academic works. There is a huge, yet heterogeneous, literature about the experience of interaction with videogames: Brown et al. (Brown and Cairns, 2004) mentioned that researchers and people use to talk about "immersion", but it is not clear if they do it in a unique persistent meaning. This problem is evident when the same term of "immersion" is referred to virtual reality experiences as well as to other kinds of software. Moreover, Brown and Cairns stated it as "the degree of involvement [of the player] with a game". "This involvement moves along the path of time and is controlled by barriers. Some barriers can only be removed by human activity, such as concentration; others can only be opened by the game itself, such as the game construction. Each level of involvement is only possible if the barriers to the level are removed. Removing these barriers, however, only allows for the experience and does not guarantee it. Three levels of involvement were found: engagement; moving on to greater involvement in engrossment; and finally total immersion.". The question, however, is still not solved and partially debated. For what concerns involvement, Calleja (Calleja, 2011) refers involvement as a model composed by six factors (kinesthetic, spatial, shared, ludic, narrative and affective) and scaled in two levels (micro and macro involvement), as resumed in Figure 4.1. Introducing its involvement model, Calleja suggested the presence of a sort of "potential" in various points of his work, alluding to
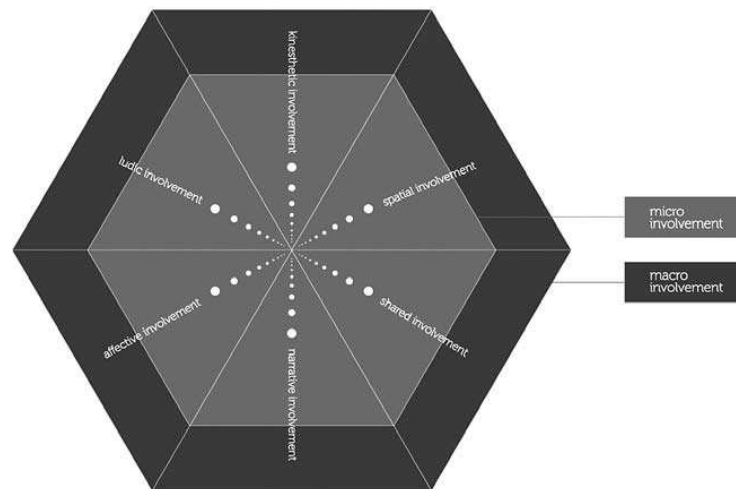
Figure 4.1: *Calleja's representation of the structure of involvement (from "In-Game: From Immersion to incorporation")*

games and, more deeply, single aspects of them (graphics, plots, technologies, gameplay models, control interfaces...) as the owner of the ability to stimulate in an interested player (initial interest is a mandatory requirement) the emergence of the various aspects of the involvement: among these, a very brief mention was also given to achievement systems ("Another example of such rewards is the achievements system common to contemporary console games", p. 161) as a factor for the ludic involvement.

Resuming, the ability to generate such interest is not a characteristic of the experience, but is a characteristic of the game, that depends from design and from the choices of the developer, that must also consider characteristics of the audience to address. As can be argued, any kind of isolation frustrates the full expression of this ability, when present. The isolation measured on the approach to serious games research affects various aspects:

- **space**: applications often are just available in a precise place on certain machines. This means that most of times the game is not reachable through the Internet or either available on machines owned by the users. This could also imply the fact that the application utilization have to be shared with other users. Obviously, this issue is difficult to avoid when dealing with uncommon access methods: it is unrealistic to think that common users could have necessary resources (finances, knowledges, time, energies) to set up and maintain operative a non-standard interaction infrastructure.

- **time**: experiences monitored by academic works are strictly limited in time. In other words, there is a lack of scientific approach on testing the impact of these instrument in education on the long run (e.g. a full school year). Tracked performances are very limited and follow precise scripts, but there is no consistent trace of further utilizations beyond the experiment and the eventual demonstration of the proposed scientific argument.

- **user capabilities**: if the final goal is the full integration of serious games in the actual

educational paradigm, the proposed framework must take into account about different ex-
igences of various educational stakeholders. Actually, all explored serious games don't
make any distinction in users between students and teachers or supervisor. This means that
teachers do not have particular capabilities, while games don't provide any kind of control
of performances and in-game students' behaviour: teachers can just supervise "from out-
side", if present when the gaming experience happens. This creates the risk of the creation
of "grey zones" where students can act without a proper supervision, exposing them to the
risk of inappropriate behaviours (e.g. bullying, as stated in (O'Keeffe and Clarke-Pearson,
2011), or addiction).

- **experience**: the experience proposed by serious games reveals to be outdated and by far
  lower, in terms of quality of service, respect to the actual products of videogames market.
  This means that a student, who is extremely probable he/she already dealt with a contem-
  porary videogame, could be frustrated or disappointed in using a product that lacks and
  misses a series of characteristics that are nowadays considered standard. This effect have
  adequately been studied by psychologists and is well explained in (Anderson, 1973): it is
  mentioned as the dissatisfaction coming from an unconfirmed expectancy.

When talking about serious games, the time spent playing includes also the time spent being
trained on the game subject and exposed to content dissemination (with positive effects, just like
in the case of (Yip and Kwan, 2006), for example). From these observations, it can be derived that
serious games holds an intrinsic ability to stimulate the player to keep learning/training his/her
skills through the time spent playing.
This, however, is a characteristic of the game, that depends from choices and actions taken during
the design and the development processes: this means that this is a richness of the game itself,
that could be catalysed and adequately supported, when deployed in an proper environment.
The downside is that, if a game has a poor potential, even the best environment would not be
able to "save the day" and create somehow a long-time engaging experience where originally
absent or poor. The point of creating good quality games is widely debated in academic works:
many authors, in fact, tried to provide guidelines for a reliable videogame creation process. In
chapter 2, it was made a precise reference to Rieber's work (Rieber, 1996), specifically designed
for serious gaming. Rieber, in facts, states that "the learner may not be interested in choosing
initially to participate in the activity or may not choose to persist in the activity for the extended
period of time at a meaningful level". In other words, "the learners must find the activity to
be intrinsically motivating" and so the motivation to play should always be a key factor for the
designers, in order to create a valuable product. Amory et al. (Amory et al., 1999) found out
that "for games to benefit educational practice and learning, they need to combine fun elements
with aspects of instructional design and system design that include motivational, learning and
interactive components". Engagement, motivation (to play) and learning are strongly linked
each other, as demonstrated by Garris et al. (Garris et al., 2002): this work also provides concrete
guidelines for the realization of a proper "game cycle" that involves and motivate the players to
play. The guidelines are articulated on six elements, resumed here:

- **fantasy**: to propose a stimulating situation that is more likely impossible or extremely rare

to live;

- **rules and goals**: to define a precise goal (or set of goals), with a set of rules to achieve them;

- **sensory stimuli**: the alternative world proposed by games is stimulating due to a different sensory stimulation;

- **challenge**: a proper challenge level is necessary to motivate the player to improve his/her skills. To find out the fair challenge level is one of the critical success factors of the game: a too low challenge level lets more players (especially younger ones) to reach quickly a skill level enough to overcome the obstacles, but also turns into a boring experience for more skilled ones; a too high level of challenge "provokes" best players to produce a higher effort and spend more time in order to beat it, but also frustrates and stimulates quitting worse ones. It have been shown in chapter 2 that one of serious games' major lacks is in challenge level adjustment: they tend to be too easy, in order to include as more players as possible, but ignoring the risk of bore average players;

- **mystery**: useful to stimulate curiosity, both sensory and cognitive. Curiosity is a fundamental pillar of learning processes;

- **control**: intended as the ability of the game to control, direct and command the content teaching and the skills stimulation.

It can be then argued that a serious game equipped with the right mixture of these factors could, then, succeed. But this is not enough, however, because there is a central question still not mentioned: the problem of the comparison of the experiences between serious games and commercial games. As exposed in chapter 2, game's efficacy could be frustrated by outdated or restricted technologies and dynamics. The case of *Opera Fatal* is emblematic: a good quality game frustrated by a poor technology development, being executable only using *Quick Time*, by far different from other contemporary games. It is a strong opinion of the author that providing an up-to-date experience is fundamental to create a long-time engagement bind between the game and the player: this comes out from the personal experience as player and from psychology literature. Anderson (Anderson, 1973) talk about this precise phenomenon from a commercial point of view: a customer is more likely to be disappointed if the product s/he handles presents a level of performance that is lower than the expected one. Figure 4.2 shows the theories posed under scientific observation by Anderson et al. The researchers stated that "the generalized negativity thesis is that any discrepancy between expectations and reality results in a generalized negative hedonic state, causing the product to receive a more unfavourable rating if it had coincided with expectations. Even if the product's performances exceeds the customer's expectations, it will be perceived as less satisfying than its objective performance would justify". Moreover, the experiments of these researchers, revealed that "there is a point which consumers will not accept increasing disparity between product claims and actual performance", so "when this threshold of rejection is reached, consumers will perceive the product less favourably than a slightly lower level of expectation". Videogames, as other products, deal necessarily with these dynamics: it
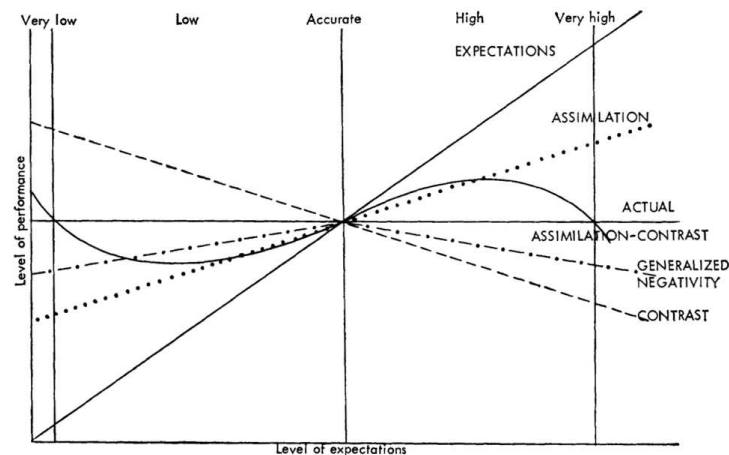
Figure 4.2: *A graphical resume of the theories of disconfirmation of expectations by Anderson (Anderson, 1973)*

is extremely improbable that a contemporary student, more likely a younger one, never had any experience with a contemporary videogame. This means that the average student acquired an idea of standard level of service, in terms of availability, easiness of access, utilization, content quality and gaming context that represent a set of expectations, even in serious game: so it will be difficult to establish the desired binding (and, then, promote the long-term engagement factor) between the user and a serious game whose performances are, as shown, by far below the threshold of rejection, even if it could have a great potential. As already declared, the goal of this work is to fill these lacks by proposing a strategy to bring the contextual services of serious games to a level comparable with the actual videogame market standards: the goal is to provide products that could properly exploit their potential.

4.2 A strategy to break the isolation

In the previous section it was shown what is intended for "isolation" suffered by serious games research and what are its repercussions. In order to overcome this issue and let serious games to be fully exploited, the author proposes his ambition: to develop a new paradigm for a new educative experience where serious games are the protagonists and the primary source of training and learning. In order to achieve this, the author proposes to import and adapt mechanisms of gaming context services proper of commercial videogames industry that are, today, de facto standard for the entertainment market. First of all, a proper definition must be provided: in literature and, so far, in these works, this paradigm has been called with various names and with vague definitions. Once and for all, here is the definition of "gaming context framework":

Definition 4.1 (Gaming context framework). A collection of online services that provide a gaming context, a virtual environment that expands and amplifies the players' experience.

In other words, these platforms provide a collection of services that catalyse the exploitation of games' potential. The proposed strategy aims at opening all the locks one by one with dedicated features, that can be partitioned into three main "pillar" features:

availability and compatibility: to solve the problem of spatial and temporal isolations, serious games must be deployed in an online framework that let the student to easily access or install the game using his/her device and a simple internet connection. In addition, it is unrealistic to think that all students are equipped with the same device. A multi-platform approach to the development must be taken into account, if we want to reach as many users as possible. Multi-platform approach is not always possible and, moreover, brings a lot of further challenges when dealing with non-common user interfaces: in these cases, when possible, the "anomalous" input system must be subrogated, in order to be compatible with common use interfaces. In fact, as mentioned in the previous section, a private user cannot have all the resources (finances, knowledges and energies) to maintain operative a system not engineered for the retail market.

gaming context : to prevent an excessive disconfirmation of expectations from the player and to prevent, then, a disaffection to the game, it was chosen to import some of the characteristics coming from the commercial videogames market. Due to the fact that some characteristics have no sense in an educational context (e.g. virtual marketplaces), while for others there must be a careful evaluation of opportunities and risks (e.g. social features), not all the characteristics are immediately adopted. The fundamental services to be provided are:

   achievement systems: a mechanism of achievement unlocking and a collection of guidelines to develop achievements for a game. Achievements of the various games are then summed in a proper amount that can be shown to other players. Results comparison is another aspect to handle with care: during their experiments on full-body interaction, De Kort et al. (De Kort and Ijsselsteijn, 2008), in fact, noticed that a public exposure brings the risk to be concerned about poor results. It have been shown that a student who experiences performance anxiety tends to produce lower results, being trapped in a vicious circle.

   player profile: player profile is necessary to give the students the opportunity to present themselves in the system as they feel to be. Avatars, pseudonyms and mottoes are common elements in every commercial videogame platform since more than a decade. It have been proved that offering customization options in terms of avatars may make games more enjoyable (Bailey et al., 2009).

capabilities diversification: as mentioned before, actually, serious games tested in an educational context do not make any distinction between the users. Educators and students are seen without any distinction by the system, despite the obvious fact they have different needs in such context. A good solution for education should, then, meet the different exigences of the main two actors in the educational scene: the student who play games and the teachers who demands tools to monitor the performances, assign homeworks, prevent risks

coming from of online communities (e.g. cyberbullying (O'Keeffe and Clarke-Pearson, 2011))

4.3   Evaluation of the proposed paradigm

In order to validate our theoretical framework, a three steps evaluation strategy is employed:

1. presentation of a collection of successful cases for similar strategies in the commercial videogames market;

2. presentation of the results of a survey submitted to players, showing the positive impact had by gaming context frameworks on videogames;

3. presentations of the outcomes from interviews to teachers and educators.

4.3.1   Successful commercial cases

Chapter 2 contains already a discussion about commercial videogames market, showing how these mechanisms were introduced and how they changed their market. In this section it will be showed how gaming context frameworks worked efficiently in the commercial viedogame market: an example of a game who had an enormous success by exploiting these kind of approach is *Candy Crush Saga. Candy Crush Saga* (CCS) is a puzzle game developed by King[1], who set the download record on the *Apple App Store* and was originally released in the 2012 as a *Facebook* game. According to (Kuittinen et al., 2007), CCS is a "casual game": in fact the game is "easy to learn, simple to play and offers quick rewards with forgiving gameplay, which all turns into a fun experience". Casual games paradigm rose up in the latest decades as a successful and a rewarded strategy, in a context where the possibility to access games multiplied also for people who are not passionate with videogames, but just aim to "kill time" in the free fragments of the day. What distinguishes a "casual gamer" from a "traditional gamer", which, in the videogames slang, is known often as a "hardcore gamer", is the quantity and the quality of the effort s/he is able to profuse in videogames. While an hardcore gamer is motivated by passion and accepts to spend time and money to play with a particular videogame (even going through technical or access difficulties and purchasing hardware designed and sold for gaming purposes, like home console systems, 3D video cards) and to keep her/himself informed about the latest novelties, the casual gamer has no particular will to play videogames: s/he is not interested on spending money (or at least not over a very low threshold), effort to gain access and time. Moreover, while hardcore gamers are interested also in videogames with a deep structure, high challenge levels and also steep learning curves, getting motivation from it, casual gamers prefer immediate games, with few rules and a gentle learning curve. Casual gamers basically exist because technology and market trends let everybody to purchase general purpose devices with increasingly higher capabilities (including playing videogames) at lower prices, opening to everybody the doors of

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[1]https://en.wikipedia.org/wiki/Candy_Crush_Saga

Figure 4.3: *A screenshot of the Candy Crush Saga game.*

gaming: before this, videogames tended to be an "exclusive" hobby for people who actively looked for them. CCS is a game that perfectly match these different approaches to videogames, turning into a download-record breaker in 2013 and producing a monthly income of 53 millions of USD in 2016 from in-game purchases[2]. Its gameplay and its "catchy" features were deeply explored in (Varonis and Varonis, 2015): here the authors propose to copy from the experience of this game to the educational field, by applying similar strategies to engage students in the same way. Since its debut as a *Facebook* game, CCS's gaming potential was fully exploited, bringing the application to a worldwide success, thanks to a strategy of development that is closely comparable to the one proposed by this work (obviously excluding the educational aspects). In fact, the original game was expanded with:

accessibility and compatibility: originally the game was a simple *Facebook* game. This meant that only *Facebook* registered users were allowed to play, excluding the rest of the world. *King* developed soon versions also for all kind of devices, letting the application to be accessible also from its own website, stopping the exclusive dependence from *Facebook*.

gaming context: *King* introduced an achievement system to its game and then exploited player community in order to enhance its product. In fact, the social component is fundamental: players can share power-ups and lives, see each other progresses in achievements and level boards, compare scores and performances.

The success had by CCS was so huge that had also some downsides, like abuse of utilization who led to addiction problems (Dockterman, 2013). CCS is the most successful case, but it is not the only one. *Zuma*[3] and the *Bejwelled* saga[4], for example, are cases who show a similar successful

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[2]https://goo.gl/K7P5X5
[3]https://en.wikipedia.org/wiki/Zuma_(video_game)
[4]https://en.wikipedia.org/wiki/Bejeweled_(series)

strategy.

4.3.2 Players' opinions

It have been shown that videogames producer and home console manufacturers introduced a new paradigm, a new gaming context framework, with the aim to provide to their users an integrated online world where they can play alone or together, interact each other, purchase more games and, in general, expand their experience with achievement systems, live feeds, live streams and many more. In order to test if players effectively recognized this as a point of no return in the videogames history and so they consider the actual level of service as a "de facto standard", an online survey was submitted to players.

4.3.2.1 Target

Target of the survey were passionate long-time players and people that had a significant time spent on playing videogames. A fundamental requirement for the subject is to have lived the moment of passage of the commercial videogames industry from the "closed" paradigm, to the gaming framework services' era. In other words, author looked for people who actively played (at least 2 games completed) at least using one videogame system up to the 6th generation of consoles and at least using one console from the 7th generation or later.

4.3.2.2 Survey

The survey consists in a collection of questions divided in 4 parts: the fist part is a registration (year of birth, sex, year of begin of player career, country), the following 2 sections ask to trace player's profile up to the 6th generation of consoles and since the 7th one (in both cases asking which devices were employed, the time spent, the services joined, the multiplayer component) and, finally, the 4th section, that is focused on the gaming framework services, asking about importance perceived for the each element and habits (evaluated through agreement to sentences expressed with Likert scales). The full survey is exposed in table 4.1. The survey was submitted to long-time players via *Google Forms*.

4.3.2.3 Analysis of Answers

Answers collected were processed using *IBM SPSS Statistics 24*. The first part of the process consisted in testing the reliability of the evaluation provided by the Likert scale based questions, performing numeric tests on the collected answers. Method used was the calculation of Chrombach's *alpha*: Pallant, in (Pallant, 2013) suggests the use of a threshold of at least 0.87 value in order to consider the set of measures reliable. Results are resumed in table 4.2. Results show that all the set expose good values of the Cronbach's alpha: the high value on the general case (where every question was counted) seems to show that the questionnaire was well formed and efficient in demanding to evaluate the feeling of the players about gaming context services. Also sub-categories showed good values, letting to use these answers to give an evaluation about players

n	**Video game player experience questionnaire**	answer type
1	*Vital statistics*	
1a	Year of Birth	free (year)
1b	Sex	radio buttons: Male / Female
1c	Country	free
1d	When did you approximatively start to regularly play video games? (enter a year)	free (year)
1e	Are you still an active player?	radio buttons: Yes, i still dedicate time and invest in gaming hardware and software / Nowadays I only play occasionally / No, i stopped playing
2	*Your player profile up to the 6th generation*	
2a	What devices have you owned among the ones listed below? (at least 5 games played for more than 20 hours per game, during ownership period)	checkboxes: Gameboy (every model up to Gameboy Advance / Nintendo - Super Nintendo - Nintendo 64 / PC Windows 95 or later / PC Windows 3.x or earlier (DOS) / Sega Master System - Mega Drive - Saturn / Sega Game Gear - Nomad - Mega Jet / Amiga Commodore / Sony Playstation / Sony Playstation 2 / Microsoft XBOX / Nintendo Gamecube / Sega Dreamcast / other
2b	How much time a week did you use to spend on games up to the 6th generation?	radio buttons: 0-10 hours / 10-15 hours / more than 15 hours
2c	Approximatively, what percentage of your gaming time was dedicated to multiplayer sessions on these systems?	free (number)
2d	Which kind of multiplayer experience did you use to have on these systems?	checkboxes: Online multiplayer / Split or shared screen with friends or relatives / other
2e	At the time, did you know about the existence of online communities devoted to support online gaming and server retrieval (like Gamespy, MSN gaming zone...)	radio buttons: Yes and I was an active user / Yes, but I never used them / No
3	*Your player profile since the 7th generation*	
3a	What devices have you owned among the ones listed below? (at least 5 games played for more than 20 hours per game, during ownership period)	checkboxes: Sony Playstation 3 - 4 - 4 plus / Microsoft XBOX 360 - One - One s / Nintendo Wii - Wii U - Switch / Nintendo DS - 3DS / Sony Playstation Portable - Playstation Vita / Pc Windows XP or later / other
3b	How much time a week have you been spending on 7th generation onward games?	radio buttons: 0-10 hours / 10-15 hours / more than 15 hours
3c	Approximatively, what percentage of your gaming time was dedicated to multiplayer sessions on these systems?	free (number)
3d	Which kind of multiplayer experience did you use to have on these systems?	checkboxes: Online multiplayer / Split or shared screen with friends or relatives / other
3e	Which of these online services have you registered with?	checkboxes: Steam / Playstation network / Xbox Live / other
3f	Have you ever subscribed to a premium account for one of the previous services? (e. g. Xbox Live Gold or Playstation Network Plus)	radio buttons: Yes / No
3g	Have you ever purchased some non gaming content (like 3d avatar skins or profile images?)	radio buttons: Yes / No
4	*Your player experience with the online game service frameworks*	
4a	Rate the features of these services with a rank from 1 (not so important) to 7 (key feature)	
4aa	Player profile: avatars, nickname and description	
4ab	Achievements / trophies to unlock	
4ac	Aggregate player scoring (e. g. Xbox Live total gamerscore)	
4ad	Social features (friends' lists and one to one chat)	
4ae	Group chat	
4af	Possibility to compare your scores with people in your friends' list	
4ag	Multiplayer organization services (e.g. "invite friends to play", clans...)	Likert scale from 1 (not so important) to 7 (key feature)
4ah	Marketplaces	
4ai	Promotions and gifts for premium subscribers	
4aj	Live feed of activity from people in your friends' list	
4ak	Possibility to share screenshots and gameplay footage	
4al	Possibility to perform or follow live streaming of game sessions (e.g. Twitch)	
4am	Media content and possibility to link to streaming services (e.g. Netflix)	
4b	Talk about your player experience with the online services appeared since the 7th-or-later generation systems. Give a rate from 1 (completely disagree) and 7 (completely agree) to these questions	
4ba	Achievements / Trophies system stimulated me to play more with some games	
4bb	I feel pleased when I unlock some Achievements / Trophies	
4bc	I feel satisfied when I unlock some high-rated Achievement / Trophy	
4bd	Sometimes, I undertake particular challenges (e. g. "The one free bullet" achievement in Half Life 2) just to unlock a particular Achievement / Trophy	
4be	I do alter my gaming behaviour in order to maximize either score or number of Achievements / Trophies	
4bf	Online multiplayer gaming is a vital part of my experience	Likert scale from 1 (completely disagree) to 7 (completely agree)
4bg	I use chat services (text and voice) provided by these services for gaming purposes	
4bh	I use chat services (text and voice) provided by these services for non gaming purposes (ordinary conversations)	
4bi	I consider people in my friends' list as real life friends	
4bj	I usually meet gaming friends in person	
4bk	I use additional multiplayer services provided by these platforms (e. g. matchmaking services, group organization...)	
4bl	I do use the unlocked achievements / trophies comparison tools	
4bm	I feel good when I have higher rankings compared to other people	
4bn	I feel bad when I have lower rankings compared to other people	
4c	Comparing your game experience between the up-to-6th generation systems and 7th-or-later generation systems, imagine that the next generation of console would come up without any service for players, except for basic multiplayer services and marketplace area, which of the following features will you miss most? Give a rate from 1 (not at all) and 7 (a lot)	
4ca	Player profile: avatars, nickname and description	
4cb	Achievements / trophies to unlock	
4cc	Aggregate player scoring (e. g. Xbox Live total gamerscore)	
4cd	Social features (friends' lists and one to one chat)	
4ce	Group chat	
4cf	Possibility to compare your scores with people in your friends' list	Likert scale from 1 (not at all) to 7 (a lot)
4cg	Multiplayer organization services (e.g. "invite friends to play", clans...)	
4ch	Promotions and gifts for premium subscribers	
4ci	Live feed of activity from people in your friends' list	
4cj	Possibility to share screenshots and gameplay footage	
4ck	Possibility to perform or follow live streaming of game sessions (e.g. Twitch)	
4cl	Media content and possibility to link to streaming services (e.g. Netflix)	

Table 4.1: *Recap table of the survey submitted to the players*

Argument	Questions	Cronbach's alpha
Gaming Context Frameworks	all questions	0.940
Achievement systems	4ab, 4ac, 4af, 4ba, 4bb, 4bc, 4bd, 4be, 4bk, 4bl, 4bm, 4bn, 4cb, 4cc, 4cf	0.922
Social features	4aa, 4ad, 4ae, 4aj, 4ak, 4al, 4bg, 4bh, 4bi, 4ca, 4cd, 4ce, 4ci, 4cj, 4ck	0.871
Multiplayer features	4ag, 4bf, 4bg, 4bj, 4cg	0.880
Marketplaces	4ah, 4ai, 4am, 4ch, 4cl	0.872

Table 4.2: *Recap table Cronbach's alpha calculations on the gamers' survey*
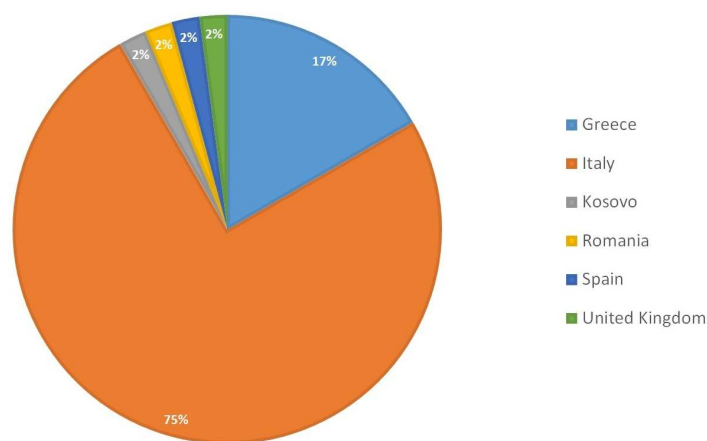
Figure 4.4: *Original nation of the interviewed.*

about single components of the adopted strategies. The only special case was given by question 4bg: "Show agreement with the sentence: I use chat services (text and voice) provided by these services for gaming purposes". This question is "border line", because talks about a social feature (chat system) employed in a multiplayer purpose: so the question fits both the categories. If removed, both "multiplayer" and "social features" expose value a few below the threshold (respectively 0.865 and 0.864). Once ensured that the measurement systems are reliable, an analysis on the outcomes can be performed. A population of 48 people was interviewed, 45 males, 3 females. Their birth date and nationalities of the respondents are resumed in fig. 4.5 and fig. 4.4. For the first analysis, all respondents were considered without any kind of distinction. Data about all these answers are resumed in table 4.3.

The seven values of the employed Likert scale were considered this way: rates from 1 to 3.5 were considered decreasingly negative to the question, rates from 3.5 to 4.5 were considered neutral, rates from 4.5 to 7 were considered increasingly positive. Answers were processed in more steps: first of all, an overall observation was performed, considering all the interviewed without any distinction and getting general results. Then, respondents were partitioned in various ways, trying to observe if there is any factor that exhibits a statistically significant difference in given answers. Factors analysed concerned registry characteristics (year and nation of birth) and player career aspects, like year of beginning of playing activity, devices owned, services subscriptions, hours spent, self-recognition as a "player". Statistical measures were performed with a T-test for independent values with a threshold of p value p ¡ 0.05 where the factor is binary (e.g. the player owns a device or not), while in other cases it was performed a one-way
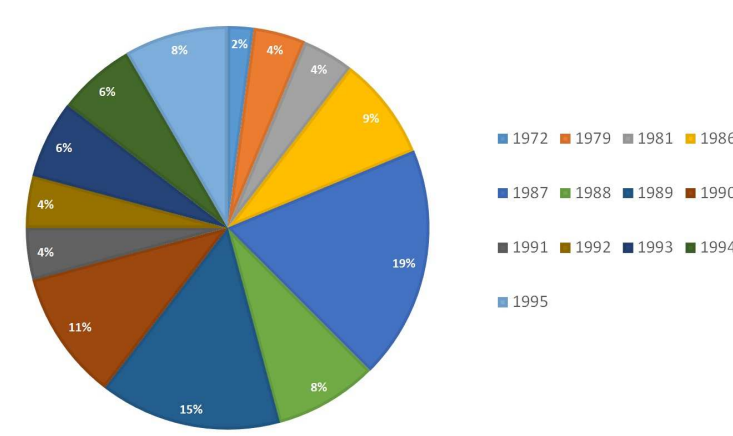
Figure 4.5: *Year of birth of the interviewed.*

Code	Argument	Average	Median	Variance	Std. dev
4aa	Social features	3.90	4.00	3.5	1.871
4ab	Achievement Systems	4.81	5.00	2.964	1.722
4ac	Achievement Systems	3.65	4.00	3.468	1.862
4ad	Social features	4.21	4.00	3.913	1.978
4ae	Social features	4.38	5.00	3.771	1.942
4af	Achievement systems	4.29	4.00	3.147	1.774
4ag	Multiplayer features	5.13	5.00	3.090	1.758
4ah	Marketplaces	4.80	4.00	3.78	1.944
4ai	Marketplaces	4.31	5.00	5.07	2.252
4aj	Social features	3.23	3.00	3.179	1.777
4ak	Social features	3.85	4.00	3.446	1.856
4al	Social features	3.71	4.00	4.381	2.093
4am	Marketplaces	3.35	3.00	3.766	1.94
4ba	Achievement systems	4.81	5.00	3.645	1.909
4bb	Achievement systems	5.31	6.00	2.985	1.728
4bc	Achievement systems	5.58	6.00	3.014	1.736
4bd	Achievement Systems	4.52	5.00	3.531	1.879
4be	Achievement systems	4.10	4.00	3.925	1.981
4bf	Multiplayer features	3.83	4.00	3.598	1.894
4bg	Multiplayer features / Social features	3.75	4.00	4.021	2.005
4bh	Social features	2.81	2.00	3.56	1.887
4bi	Social features	2.65	2.00	2.957	1.72
4bj	Multiplayer features	2.67	2.00	3.418	1.849
4bk	Achievement systems	2.90	3.00	3.755	1.938
4bl	Achievement systems	3.23	3.00	3.585	1.893
4bm	Achievement systems	4.29	5.00	3.7	1.924
4bn	Achievement systems	2.63	2.00	2.239	1.496
4ca	Social features	4.08	4.00	2.887	1.699
4cb	Achievement systems	4.73	5.00	4.627	2.151
4cc	Achievement systems	3.31	4.00	3.666	1.915
4cd	Social features	4.15	4.00	4.34	2.083
4ce	Social features	4.21	5.00	4.296	2.073
4cf	Achievement systems	3.44	3.00	3.698	1.923
4cg	Multiplayer features	4.48	5.00	4.00	2.00
4ch	Marketplaces	3.77	3.00	5.202	2.281
4ci	Social features	3.10	3.00	3.797	1.949
4cj	Social features	3.83	4.00	4.099	2.025
4ck	Social features	3.40	3.00	4.797	2.19
4cl	Marketplaces	2.92	3.00	4.291	2.071

Table 4.3: *Recap of all statistics about all answers for all questions*

Figure 4.6: *Boxplot of question 4ab with "period of birth" factor.*

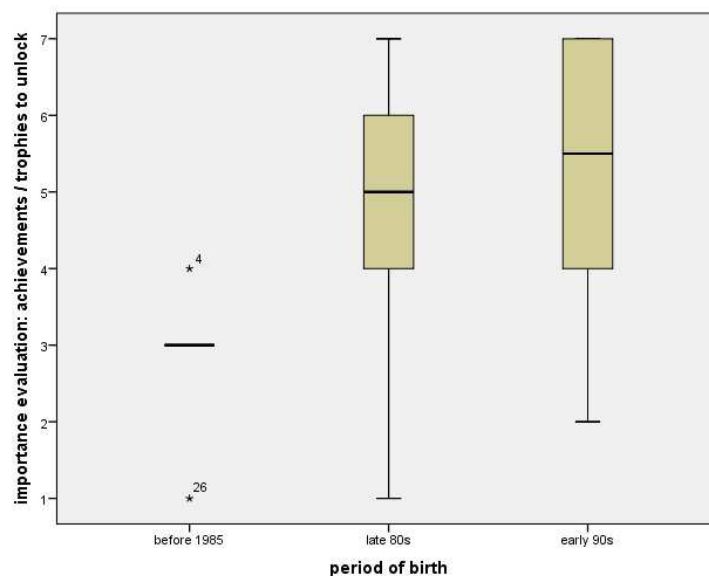ANOVA with a significance threshold of at most 0.05. Data observed show that players tend to give value to the various components of the observed service paradigms. Achievement systems obtained good ratings in terms of importance (questions 4ab and 4ba) and missing in case of an eventual disappear (question 4cb). Players give value to the achievement as a personal reward (question 4bb and 4bc), showing an inclination to undertake some particular challenges (that they would have never taught) in order to chase particular achievements (question 4bd): the curious fact is that they are more likely to chase these very unusual challenges rather than altering in a minor, but "long-time", way their gaming style in order to catch the more achievement they can (question 4be). Moreover, Achievement systems seem to be the characteristic that players would miss mostly (question 4cb), even if the high variance (4.627) suggests that there are discordant opinions on it. Birth year revealed to be a key factor in this (Figures 4.6 and 4.7), revealing that the so-called "millenials" (people born at least in 1985) showed to be statistically significantly more interested in achievement systems than their older colleagues (ANOVA significance 0.13 for question 4ab, 0.15 for question 4ba, 0.45 for question, 0.08 for question 4cb). A particular attention deserves the question 4ba, that is vital to our purposes. Younger interviewed players showed that they feel stimulated by achievement systems to play more with games (Figure 4.8): this is one of the key goals of the project and this survey seems to suggest that the strategy proposed could be a winning strategy to engage the player/students to play and get trained by serious games. Social features received an overall neutral response from the whole population of the interviewed: moreover, as can be seen from ratings to questions 4aj, 4ci and 4ck, they tend to not care too much about social features beyond those strictly connected to the gaming experience, like friends lists and basic one-to-one and group chat. Factors that play a role in the social features perception are the subscription of a gaming network service and the actual self-recognition as a "player". Subscribers of services are more likely to be usual to these mechanisms, so it is obvious
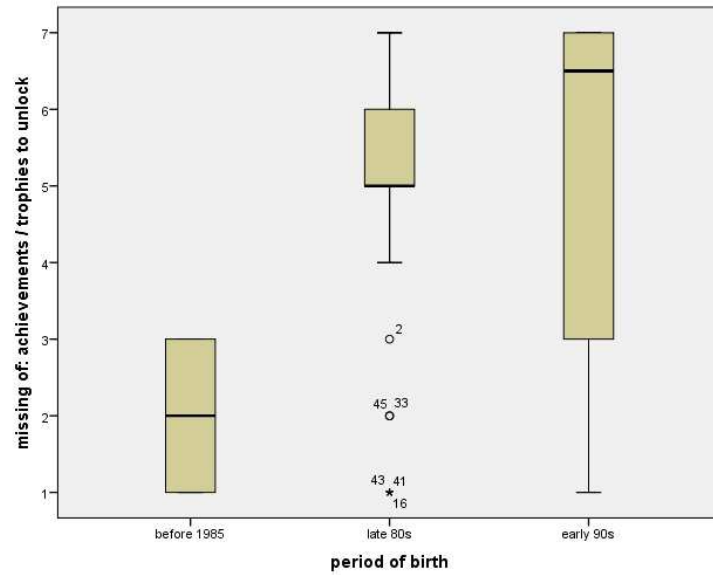
Figure 4.7: *Boxplot of question 4cb with "period of birth" factor.*
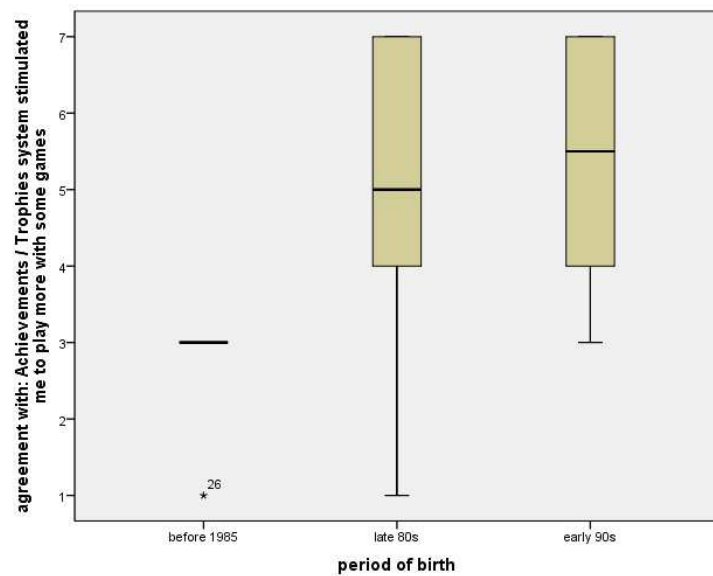
Figure 4.8: *Boxplot of question 4ba with "period of birth" factor.*
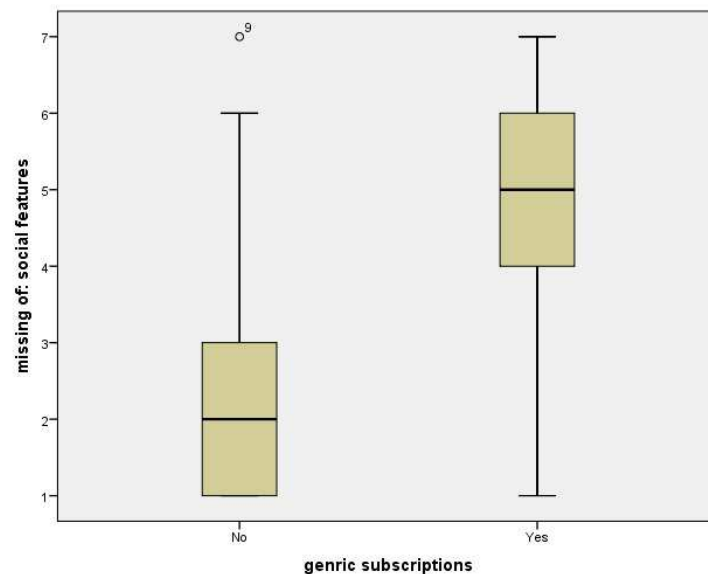
Figure 4.9: *Boxplot of question 4cd with "ever subscribed to a gaming context service" factor.*

to expect from them a disappointment for a lower level of service, like mentioned by Anderson (Anderson, 1973). Multiplayer features are crucial for all the players: question 4ag shows the highest average (5.19) of rating among the importance given to the various aspects of the gaming context services experience. However, this is a quite extreme case: as can be seen in table 4.3, other questions about the argument received a neutral response. Here the key factors are player activity, intended as the condition of self-recognition as a player and hours spent on the latest devices, alongside with the fact of having subscribed to a gaming context service. People who perceive themselves as "gamers", in fact, show significant differences for questions 4ag and 4bk, while people who subscribed a service or spend more hours on gaming, tend to consider multiplayer as a fundamental part of their experience (question 4bf)(Figures 4.10 and 4.11) Finally, the aspect of marketplaces, which is out of the scope of our work for the aforementioned reasons. Question 4ah showed a good response from the interviewed and, as could be expected, premium service subscribers give a higher value to marketplaces, with their promotions, together with connections with external media provider (e. g. *Netflix*).

4.3.3 Teachers' opinions

After investigating player's opinion, it is mandatory to collect and consider the opinions of other main actor of the scene: educators and teachers. For this purposes, music teachers coming from lower secondary school were interviewed. While, on the players' side the modus operandi consisted in an on-line survey, trying to reach as many players as possible, teachers underwent singular one-on-one interviews. The method employed for analysis of this data in inspired by the work of Brunardl (Burnard, 1991), that is widely recognised ad a reference for this task. The choice of having music teachers was due to a simplification of the process. At our research
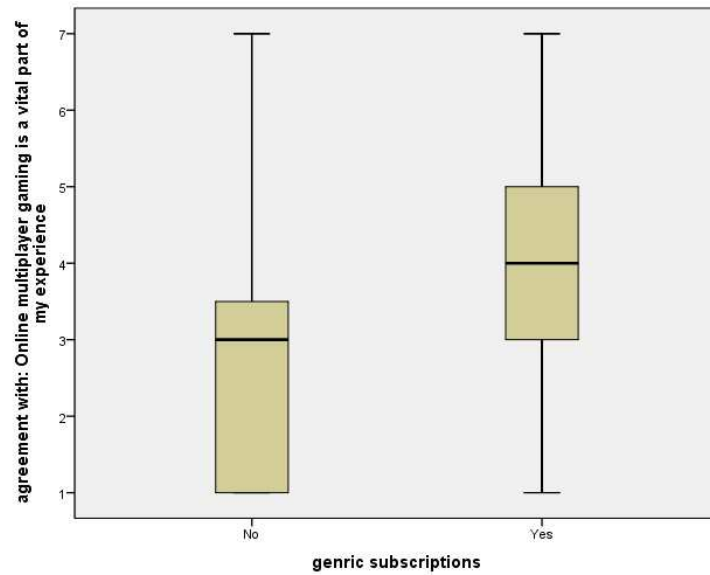
Figure 4.10: *Boxplot of question bf4 with "ever subscribed to a gaming context service" factor.*
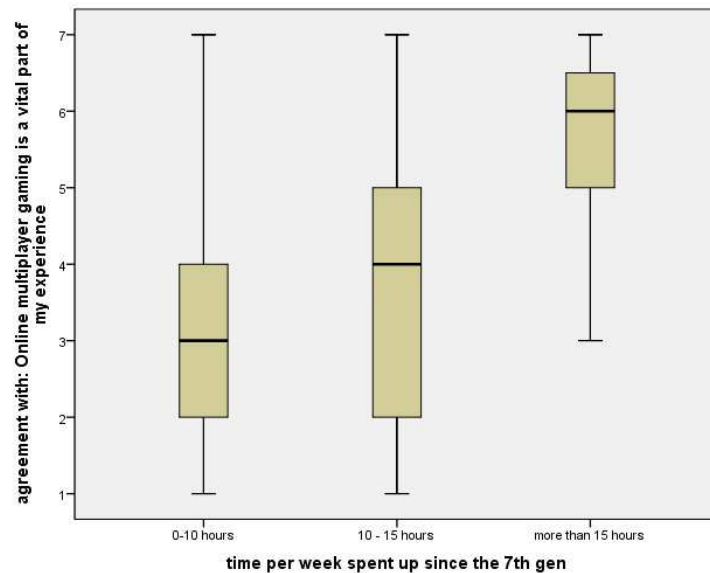

Figure 4.11: *Boxplot of question bf4 with "time per week spent with 7th gen or later devices" factor.*

center, we already had proficient collaborations with some of them for other research projects on serious games (like "Harmonic Walk"), so they are people experienced with employing serious games in a scholastic context and could understand the scope of the project in an easier way. In other words, the possibility to exhibit some concrete examples of serious games that could benefit from these proposed guidelines simplified a lot the explanation and the understanding for the subjects, that often never had a significant videogaming activity or experience. The method, adapted and simplified, will follow these steps:

1. Interviews are collected, using a semi-structured plot, shown below.

2. Interviews were spooled and transcribed one by one, marking and tagging all significant passages expressed. With the term "tag", it means that a recognized assertion in the interview is, on the first instance, marked as "significant" and then, on a successive passings, grouped on various categories. The goal of this refinement process is to produce a proper distinction between different categories of sentences, distinguishing between, for example, desirable features and required features critical for platform success.

3. Categorization is validated through an agreement test delivered to few selected colleagues. The goal is to understand if other people would provide same categorization for the same set of sentences.

4. Validated results are resumed and put into a discursive form, obtaining a proper conclusion.

4.3.3.1   Target

Target of the interview were 4 music teachers coming from lower secondary school. This choice was to keep a continuum with the previous work run at the Sound and music laboratories. Some of the teachers interviewed, in fact, were already involved on the projects about "Harmonic walk" testing with Ph. D. graduate Marcella Mandanici (Mandanici, 2016). On the other hand, the choice of an homogeneous group of people let the answer set to be more consistent and reliable.

4.3.3.2   Interview model

Interviews were semi-structured, using the following plot:

1. **Presentation of research area:** quick introduction to the research area of interest, introducing serious games and some fundamental findings about engagement on serious games, *gamified* activities and experiences.

2. **Presentation of progresses:** an excursus about the whole work and progress on the research conducted at the Sound and Music Computing Laboratories. Teachers got some hotspots about findings, progresses, future developments.

3. **Introduction to context gaming services and possibilities in educational world:** an explanation of what are the context gaming services and of the idea to use them not only for commercial purposes, but also to fully exploit serious games' potentialities. Introduction

to the concepts of achievements, social networking in games, competition through high score rankings. Showing of an actual commercial example (the "Xbox Live" platform).

4. **Question 1:** Considering the porting of such mechanisms to the scholastic world, what are, in your opinion, the strengths and the weaknesses of such approach?

5. **Question 2:** What are, in your opinion, the features that a teacher would require in order to employ such instruments in a scholastic context?

6. **Other observations and opinions:** teachers loved to expose and tell their opinion about games, particularly they indicated some characteristics that games should have in order to result effective for platform success.

Interviews were all kept face to face at author's workplace at the SMC laboratories and recorded using his personal smartphone.

4.3.3.3   Refinement and validation

Interviews were spooled one by one, marking and tagging all significant passages expressed. With the term "tag", it means that a recognized assertion in the interview is, on the first instance, marked as "significant" and then, on a second pass, grouped on various categories. The goal of this refinement process is to produce a proper distinction between different categories of sentences, distinguishing between, for example, desirable features and required features critical for platform success.
During the refinement process, 4 different categories were identified:

- **Requirements**: features reputed to be strictly required to run and work in a school context. Teachers consider these features as mandatory.

- **Opportunities**: strengths and positive effects that the project could have in an educational context.

- **Risks**: risks coming from potential problems due to the nature of the project.

- **Suggestions**: various suggestions about services or games to develop.

All the collected assertion, refined of double entries and categorized, are resumed in table 4.4.

After extracting all the sentence set, extracted features are validated with a randomization process, in order to certificate reliability.

4.3.3.4   Validation

As mentioned by (Burnard, 1991), validation of qualitative research is always a critical task and exposes collected data to criticisms and doubts. It was chosen to follow Burnardl e al. prescription to achieve this goal in a secure way. A random subset of 10 extracted elements was

	Interview subject			
Topics and keywords	1	2	3	4
Requirements				
Teachers must have an absolute power over the social components of the framework	x		x	x
Sensible data (biometrics, performances, evaluations...) must be secured	x			
This framework should let teachers to deliver assignments	x			
The technology should be easy and quick to teach	x			
Games should help the teacher to deliver most difficult passages of the teaching through easy operative instructions	x			
Games should stimulate interest over conceptually easy elements	x			
Games' quality should be equally high	x			
Teacher should have the power to lead the game and, eventually block players or halt in classroom execution	x	x	x	
Teachers should have the possibility ho help and deliver suggestions to students	x		x	
Inclusion of impaired students in unavoidable	x			x
Impaired students experience should be perceived as equal by all students	x			x
The system must have a pleasant graphics/audio and not explicitly "serious"	x	x		
Teachers need to see and evaluate performances	x	x	x	x
Keep the focus on the quality of the tasks, rather than quantity			x	
Achievement must be centred on topics discussed in classes			x	
Opportunities				
Competitiveness could be a positive factor if oriented to education	x			x
Delivering assignments through this framework could be useful and fun	x	x		
A framework "closed" to the students' world could catch their attention	x		x	
Teaching while entertaining is the best	x		x	
Serious games could be useful on delivering theoretical difficult concepts	x			
All the context and the scores idea could engage the students and let them con front and talk about it	x			
In cooperative tasks, everyone's part should be different and equally important to the task resolution	x			
Prizes not only for results, but also for cooperation quality	x			
These kind of technologies represents the future of education		x		
Students are heavily interested on technology		x		
Differentiation of educative offer is good when dealing with students that are all different one from each other		x	x	
These technologies are very useful to develop cross competencies	x			x
Promote a positive competitions between groups of students ("Olympics")	x			x
This framework could be useful to involve students with topics generally considered boring or not interesting				x
This technology could be a "door" to perform a better inclusion for impaired students				x
This could help to understand learning efficiency on a wider scale and keep the level homogeneous				x
Risks				
Excessive competitiveness could be dangerous	x			
Cyberbullysm is a huge problem	x			
Sore exposition could lead to awareness for lower ones	x			
Don't overestimate students' competencies when defining tasks	x			
"too serious" games would increase the distance with students' world	x			
Target students vary a lot with ages	x			
If games' quality is unbalanced, students will tend to ignore lower quality ones	x			
Technology in school is heavily flawed	x	x	x	x
When providing a non-standard lesson, involving computers and interactions, the cost of a productive hour is very high	x			
Some students could be annoying just for the fun to be	x			
Competition could be to frustrated or angry students, useless for learning	x			
It could be dispersive for educative purposes			x	
Suggestions				
A good game should have a quest that is unrelated with the topic to teach	x			
Design collaborative multiplayer games	x	x	x	x
Tasks could be prepared a priori, letting the teacher to have a easier control			x	
The teacher could be a special character to interact with, with particular in-game functionalities			x	

Table 4.4: *Resume of teacher's opinion about the proposed framework*

Question	Average	Median	Variance	Std. dev
1	5.83	6.00	1.37	1.17
2	4.83	5.50	3.77	1.94
3	4.67	5.00	2.27	1.50
4	4.21	6.00	1.50	1.23
5	5.33	6.00	3.45	1.86
6	5.33	5.50	1.47	1.21
7	5.50	6.50	5.50	2.35
8	4.33	5.00	3.87	1.97
9	5.83	6.00	0.57	0.75
10	6.33	6.00	0.27	0.52

Table 4.5: *Recap of all statistics about validation questionnaire*
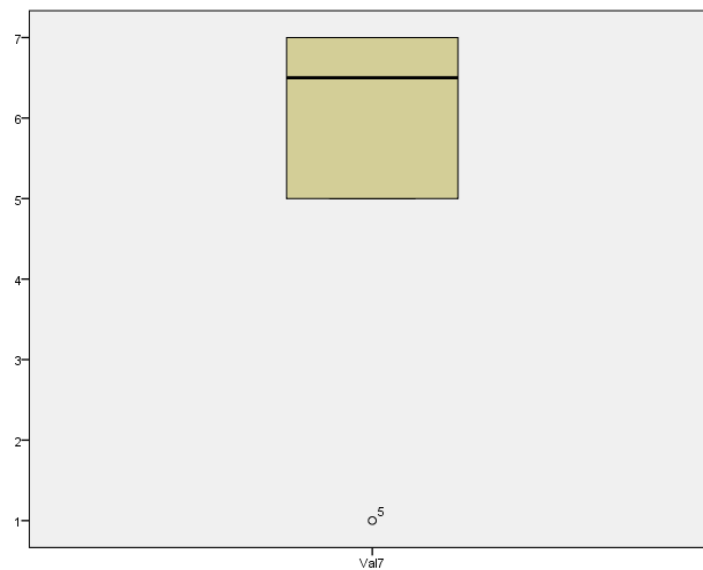
Figure 4.12: *Boxplot of question 7 of the validation questionnaire.*

chosen and submitted to 6 colleagues who acted like reviewers. To them was asked to answer a brief survey built with 7 values Likert scale. The questions were about to express agreement with the classification process outcomes, reporting the interview snippet, the extrapolated sentence and its classification: value 1 express disagreement, value 7 complete agreement, while 4 were considered as a neutral answer. Results are resumed in table 4.5.

Results show that interviewed colleagues generally agree with the expressed evaluation of the sentences: in particular, looking at the averages, there was a mild agreement in 4 questions (2, 3, 4, 8), a solid agreement in 5 of them (1, 5, 6, 7, 9), while question 10 had a very strong agreement. Sentences with a mild agreement tend to present higher values in variance and standard deviation values, but a median value never under 5 showed that the majority of reviewers agreed with the proposed sentence. For what concerns variance and standard deviation values, most critical sentence was the 7th, that presents highest values. The snippet was "Subject: you must think about platforms, eventually simplified ones, to deal with physical impairments or limitations. Disabled students cannot be left to perceive themselves "different" than the others" sentence extrapolated was "'inclusion of impaired students in unavoidable' is a REQUIREMENT". Boxplot about these answers are displayed in figure 4.12.

The boxplot clearly showed that those high values were due an outsider (the 5th answer), while majority of answers were 5 or higher. This confirms that the fact of having high values in standard deviation and variance is due to the small size of answers set (just 6 elements).

4.3.3.5 Outcomes

After collecting opinions from gamers and teachers, enough informations were collected in order to refine the proposed framework and try to collect all the possible advantages and limit risks.

1. **Achievement system**. Achievement system was universally approved: not only, it was also pointed as a possibly smart tool to perform assessment and homework delivering.

2. **Social features**. Social features were approved, but raised major worries from teachers: on one hand, player does not evaluate them so fundamental, outside mere gaming purposes, on the other hand, teachers required expressively a total control about communications. Controlling all communications would raise some extra issues that cannot be underestimated, like a huge overhead for teachers and also legal issues about students' privacy (it is not possible for teachers to "spy" communications between students). So it was decided to limit social features to profile customization, but without direct chat communications.

3. **Multiplatform approach**. It was noticed as extremely important to let students to use their devices from home, in order to increase the involvement of students and to overcome to the difficult of schools and institutions to provide proper equipment for every student.

These guidelines were employed to create a refined framework, proposed in Chapter 5. As can be seen, all the collected and refined outcomes are completely uncorrelated with the discipline taught by interview subjects (music education). Author had the precise goal to refine and clean up the final outcomes from any reference to a specific argument or skill, due to fact that the framework proposed is thought to be general purpose.

Chapter 5

Conclusions and further developments

If there's a new way, I'll be the first in line, But it better work this time
(Megadeth - Peace Sells)

In this chapter there will be the presentation of the conclusions of the work and the further developments. This chapter will introduce and explain a prototype devoted to put in concrete conclusions obtained so far. The prototype is currently under construction by the author's research group. The acronym used to identify the software is "PONG", which is a symbolic homage to Pong, the historic totem of the earliest videogames history[1].

5.1 The "Good or Bad?" experience and the study of full body interaction's role in serious gaming

The *Good or Bad?* game, presented in 2 provides to users the possibility of listening music in an unusual way. Exploiting the characteristics of multi-track recording, the game allows a deeper understanding of the existing relationships among musical parts inside a polyphonic music score. This opportunity, once allowed only to professionals, is now available for everybody through an engaging and playful approach. Of course, a computer endowed with a musical editor would offer even further insights on musical compositions: however, most of the times these devices are not in the reach of the greatest number of people. Moreover, also professionals do not listen for a long time to single instrumental parts if not compelled by a particular task, or problem to solve. Thus *Good or Bad?* not only provides a song multi-track recording in a handy way, but also realizes the mechanism that makes its fruition possible and necessary.

The *Good or Bad?* game has been tested both in controlled and uncontrolled condition, arising a great interest from the users. Also if an improvement of the music listening skills could not be proved, the game's use allows a better confidence from subjects. Moreover, thanks to full-body interaction and immersion, *Good or Bad?* is able to obtain a high degree of players engagement. For what concerns learning, experiments conducted show that full body interaction's role seems

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[1]https://en.wikipedia.org/wiki/Pong

to be neutral. However, research approach to this field appeared to be flawed at least in two aspects: length and amplitude of the subjects exposure and caring about the overall quality of learning experience. Further experiments with other games are necessary and the key could be to increase the task required (and the game's complexity) and observe the phenomenon over a longer time lapse, with a repeated exposition to the game and the infrastructure.

5.2   A new paradigm of educative experience

During this work, an exhaustive analysis of the world of serious games was performed (see chapter 2) and outcomes of this investigation unfolded all their limitations. Serious games often suffer of low quality performances, low level of challenges (in order to let everybody to be able to play), inadequate technological level, quality of service by far lower than contemporary commercial videogames. This turns into a unsatisfactory experience for players, especially younger ones, who tend to abandon the games earlier than forecasts. Moreover, research approach lacks in evaluating impact of such tools on the long run, in terms of engagement and learning efficiency. In order to overcome these problems and propose a solid long term experience, a gaming services framework for serious gaming, defining a new educative experience, is proposed. The guidelines import some of the winning strategies of commercial videogames producers, like achievement system, social features, empowered accessibility to games and features. The framework was both validated with an *ad-hoc* survey for the players, demonstrating the appreciation that such services have when dealing with contemporary videogames, and with open interviews to teachers. Teachers recognized the validity of the approach to the problem, showing enthusiasm and ideas to enrich the project, evidencing the critical points and suggesting solutions. The validated framework is employed on the modelling of a concrete prototype, the PONG project.

5.3   Prototype implementation - PONG project

5.3.1   Modelling

5.3.1.1   Goals of the technology

The main goal of the technology is to provide a gaming context framework dedicated to the serious games. This framework will import and implement in the serious games field good practices and common policies oriented to the enhancement of the involvement level. The goal is to create an infrastructure that is comparable to the actual contemporary platform existing in the commercial videogames market, with the proper modifications to respond to educational purposes.

5.3.1.2   Requirements

The service will be accessible from everywhere on the internet, compatible with various platforms (pc client, web browser, *Android/IoS*, Interactive space) and will provide the possibility
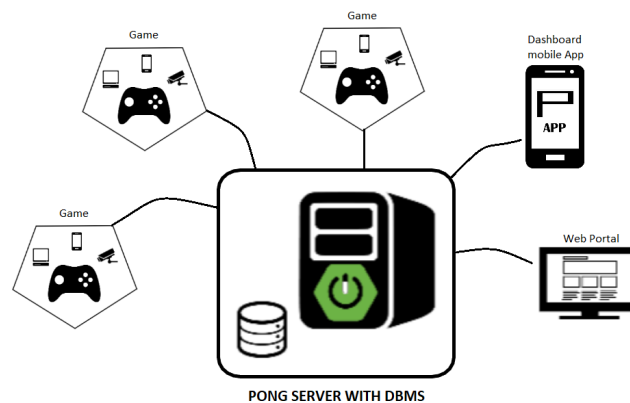
Figure 5.1: *Sketch of the PONG infrastructure*

to play games from each one of these. The service will also let the teacher to control student's behaviour and provide tool to try to influence them to follow some precise learning paths. The pillar concepts of the structure, coming from discussion in 4, are:

- **Accessibility in space, technology and time**. A web service deployed in two components: a back-end service to handle data and expose *API REST* to the outer world, and a front-end service (a website) for user interaction. Applications and games will be playable on personal computers and most of mobile devices available in the market. Approach to the utilization paradigm will shift from a centralized-only policy (the institution provides to the users the devices to interact with the application) to an hybrid of a centralized approach (the institution will still provide some devices for in-classroom use, e. g. a tracking system) with an *UYOD* philosophy (Use Your Own Device). It is fundamental to let the students reach the applications with their devices when they are not in classroom. Games and dashboard will be available via mobile applications, desktop applications and *HTML* portal.

- **Engagement and immersion empowerment**. Nurturing engagement and keeping the users to will to use spontaneously with the infrastructure will be fundamental for the success of this strategy. An achievement system will be integrated in the framework, letting the users to accumulate points and trophies and compare results each other. Social aspects of the experiences are useful to stimulate a sane competitive spirit among the users, but limitedly, in order to stem risks, as highlighted from teachers.

- **Capabilities differentiation**. Different actors will have different roles in the system. Users that play the games and participate in the network and teachers or educators that have the key role to control behaviours and monitor performances. They must also be provided of the instruments necessary to act quickly in case of necessity and to be able to drive users performances to a precise goal.
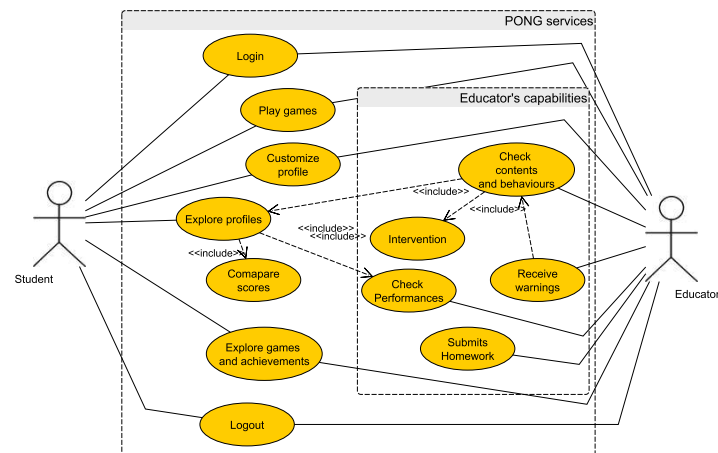
Figure 5.2: *Use cases for PONG portal*

5.3.1.3   Actors

The usage scenario will include the following actors:

- **Students / users.** They are users of the systems. They can edit their own profile, see their in-game progresses and list achievements and, obviously, play games. They play games on various devices and get a real-time feedback of their progresses (achievement unlocking is notified via pop-ups). Prior to do every action, they must authenticate to the system. They could be administered in groups, organized by educators and teachers: every member "sees" his/her mates and their profiles.

- **Teachers / educators.** They have the role to monitor and manage students and group of students. Due to fact they have the responsibility of students' behaviour and skill progresses, they can control them. They have also the ability to block users, games and try to suggest or force their in game behaviour. Prior to do every action, they must authenticate to the system.

- **System administrators.** Technology expert with administration powers. They have the competences necessary to maintain the infrastructure healthy and working.

After the collection of the requirements, a first sketch of the PONG prototype is showed in 5.1.

5.3.1.4   Use case scenarios

This section will introduce expected use cases. Web portal is the main operative centre of the whole structure. Here lay all the functions, the controls and services dedicated to the two actors of the system.
Generic user's use cases are detailed below:

- **Login**:

1. Unauthorized user tries to accesses a page and is redirected to the login form page.

2. User provides credentials.

3. If credentials are correct, the system recognizes his/her role and redirects navigation to the respective personal home page.

- **Play game:**

  1. Authorized user accesses to the game page.

  2. User clicks a "Play" button to start playing.

  3. User is redirected to a page that embeds the *Unity web player* instance that executes that game.

  4. User plays the game.

- **Customize profile:**

  1. Authorized user accesses to the personal page.

  2. User clicks a "Edit" button to start editing.

  3. User is redirected to a page where he/she can change his username, bio, and update profile image (picking it among a set).

- **Explore profile:**

  1. Authorized user accesses to the page of his classmates or of the group he belongs.

  2. User clicks the profile of one of them.

  3. User is redirected to a page where he/she can find mate's personal profile (image, bio, global score).

  4. If the user has the role of "Educator", he/she can click the "Check performances" button and activates the "Check performances" use case.

  5. If user clicks on "Compare achievements" button, the "Compare achievements" use case is activated.

- **Compare achievements**

  1. Authorized user accesses to profile page of one of his/her mates.

  2. User clicks on "Compare achievements" button.

  3. User is redirected to a page displaying all the games, with on the left his scores, on the right the scores of his/her mate.

  4. If user clicks on a game, the exploration goes deeper: here a user can check, achievement by achievement, the performances.

- **Explore games and achievements:**

1. Authorized user accesses to the personal page.

2. User clicks a game from the list.

3. User is redirected to a page where he can find personal game portal.

4. Here user can check the achievement list relative to this game, showing unlocked ones and locked ones. Here the user can check single achievement value and the description, that communicates the unlocking conditions.

- **Logout:**

  1. Authorized user clicks on the "Logout" button or quits the browser.

  2. If he/she manually performed the logout, he/she is redirected back to the login page.

As anticipated earlier, there will be capabilities and features, which will be exclusively dedicated to users with the "Educator" role. These users will figure in the following use cases:

- **Administer content and behaviours:**

  1. Authorized educator accesses to the page of his groups and selects one.

  2. Educator selects a student by clicking on his profiles.

  3. Educator accesses the student's profile and checks that does not contain inappropriate material or an incorrect usage (e. g. excessive utilization).

  4. If necessary, Educator can intervene,going through the "Intervention" use case

- **Receive warnings:**

  1. Authorized educator receive a warning from an external actor (e. g. a parent).

  2. Educator checks the relative user's profile and goes through the "Administer content and behaviours" use case.

- **Intervention:**

  1. Authorized educator measures an incorrect or inappropriate utilization from a student

  2. Educator use his intervention tools:
     - editing of student's profile;
     - student's account suspension.

  3. Educator can communicate via email the action taken.

- **Check performances:**

  1. Authorized educator accesses to the page of his groups and selects one.

  2. Educator selects a student by clicking on his profiles.

3. Educator accesses the student's gaming records by clicking the "Check performances" button.

4. Educator is redirected to a page with all the games and general utilization statistics (e. g. global score, time of utilization, latest accesses).

5. Educator can go deeper in exploring performances of a particular game and check achievements progresses.

- **Prepares Homework:**

  1. Authorized educator accesses to the page of his groups and selects one.

  2. Educator prepares some special achievements for some games and sends a notification to students, asking to complete them.

5.3.2 Implementation

5.3.2.1 Back-end component

Back-end component of the server will use the *Spring Boot* framework. The name "Spring" represent a huge collection of *Java* projects aimed to the development of web services and applications.

Spring framework is rising up as a big competitor in the scene of frameworks devoted to the implementation of back-end components of web applications, and now has become a real competitor of Microsoft's *.NET* framework, with the fundamental advantage to be covered by an Open Source license. *Spring*'s pillar is implementation of the concept of *Inversion of Control* (IoC) via *Dependency Injection*, introduced by Fowler in (Fowler, 2004).

Spring boot[2] is a particular descendant of the *Spring* family, whose main particularity is to be able to self-discovery beans in the code, boosting developer's productivity by cutting the necessary configurations step.

5.3.2.2 Clients and front-end applications

PONG back-end services compose the structure functional to the data exposure to the world. Through APIs designed and exposed, is possible to fetch and manipulate data, performing requested applications. Humans directly fetch and manipulate data through the front-end component. This application exposes a GUI (a web page) to the user, and represents one of the the main doors through which he/she can utilize the PONG infrastructure. This application includes:

- **a web portal** designed in *HTML*, extended with *FTL*, an add-on that provides endpoints to fill the page with data from the back-end, as designed by the *Apache FreeMarker* project. This portal will be the main access point for users and teachers. Separate view will let users to see their progresses and interact with other users, while teachers will have exclusive views, functions and aggregate statistics, useful to realize their purposes.

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[2]https://projects.spring.io/spring-boot/

- **Dasboard app** with similar functions and informations of web portal, but with a more pleasant and interactive user interface. One of the hypothesis is to develop it using Unity framework, in order to exploit its multiplatform vocation and obtain, with just one development process, an application compatible with *Windows*, *Mac OsX*, *iOS*, and *Android* platforms.

Other access method will consist in access through games. Games, in fact, will be directly accessed through the front-end application or as standalone applications deployable on other devices. Prior to the access to any gaming content, credentials must be provided. Unauthenticated access to the applications will be forbidden, in order to keep trace of players' actions and performances. Games are developed in *Unity 3D*, aiming to exploit the multiplatform features of the engine. Games will be accessible through the web portal (using the *Unity web player*), mobile devices (compatible *iOS* and *Android* devices), workstations (*Mac OsX* or *Microsoft Windows* platforms): besides the possibility to run games in all such contexts, they will be designed and developed in order to be compatible with different access systems. The idea is to prepare games compatible through all technologies tested in our laboratories (interactive spaces, touch screen, mouse and keyboard).

5.4   Further developments

Following to the prototype completion and deployment, developments to this projects are in two directions.

First of all, the prototype must be tested and measured on a real classroom of students, evaluating behaviours, impact and effects on concept learning and skills training. This requires an active collaboration with the schools, that should host and submit it to their students. Tests mus be conduced on middle and long runs, in order to test the solidity of the proposal even when the "novelty effect" is dissipated. This will be fundamental not only to test the quality of the developed solution, but, obviously, to empirically certify the validity of the theoretical framework, expressed in form of guidelines, that represents the core of the thesis.

Second, a solid dialogue and collaboration with educators must be taken into account. This collaboration is oriented not only on the continuous enrichment of the proposal, but also on games designing. More concretely, the goal could be the definition of a meta-model for serious games, in order to ease development of new solutions: a set of rules that let educators to build up their own game with the less effort possible, in a friendly way.

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