Methodology and a technological framework to maximize learning in a development of serious games distance course and the evaluation of learning

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Abstract. **The goal of this article is to present an interactionist methodology of learning support and a framework consisting of technological tools used to support it, which was used during an e-learning course on development of serious games applied to education for the students of a computer science graduate program. The methodology was based on dynamic learning support and assessment of learning, called pedagogical architectures that combine pedagogical strategies with technological resources to achieve the pedagogical objectives. The pedagogical strategies favored a cooperative construction of knowledge, debates and systematic reviews of the productions by the peers, successive refinements of these productions, based on feedback from colleagues, and learning by doing. To support the educational strategies, it was decided to compose a technological framework with software and web services, free for educational purposes that maximizes learning and would provide a continuous and distributed evaluation. Such technological framework comprehends software and services available on the web for communication, recording and storing knowledge, collaborative construction documents and video games construction. The evaluation of the methodology and the technological framework used during the academic semester has revealed significant results that are described in this paper.**

Keywords—Computer science education; serious game development; serious games in education.

1. INTRODUCTION

Education can foster innovation and creativity in the society. Further, it is important to help students to be better citizens who can think and act towards a better world for everyone. Although this is the common sense among educators, resources and current teaching methods still cannot shake off the traditionalism that favors the replication of the already established knowledge. It is clearly visible that the majority of educational institutions persist to use traditional formats of classrooms (e.g. several desks arranged one behind the other) and teacher-centered dynamics wherein the teacher is the issuer of all the knowledge that the students must absorb in a disciplined manner. Thus, there is an urge for new pedagogical approaches that boost learning and transform the traditional teacher-centered dynamic into a more student-centered one. In this context, the importance of the teachers goes beyond the presentation of content and test application, but it also comprises the learning mediation.

In this context, games are being increasingly used as teaching tools to enhance learning [1,2]. The use of technology can also contribute significantly to the development of the individual. The combination of games with digital technologies has given rise to the video games. When applied to education it enables the individual to benefit from these two resources [3].

Recently, the video games developed without entertainment as its main purpose began to be classified as serious games and, among them, are the video games for educational purposes [4,5]. Due to the expansion of the use of serious games, the market for the development of this type of video games has emerged as one of the most promising for the computer science professionals. However, the successful introduction of serious games in education depends on, among other factors, a good education level of the professionals involved in their creation, especially the software developers. In this context, there is a need for these professionals to know: how serious games can be applied to support learning, which gaming characteristics favors the learning, what are the specifics of design and construction of serious games, besides the resources that can be used for their development and evaluation of the learning afforded by them [6,7]. It is also necessary that these professionals learn skills and develop attitudes that are important in the serious games development process, such as creativity, teamwork and criticism [8].

This article reports the successful use of an interactionist methodology of learning support and a framework of technological resources during an e-learning course about development of serious games applied to education for students of a computer science graduate program in a Brazilian university. The methodology was based on the concept of pedagogical architectures and was composed of dynamic cooperatives and information technology resources aimed at: encouraging participation, the exercise of creativity, learning in practice, the collaborative construction of knowledge and, continuous and distributed evaluation [7,8]. This paper discusses the reasons that led to the creation of this methodology, a brief description of it, the technological framework proposed to support it, the learning and the results of its use, the most relevant conclusions of the work and the actions planned to the future.

II. Serious Games Applied to Education

The games have always been a form of education, from the earliest to the latest technology [1]. Fantasy is an important component to human being: leisure, games, arts, etc., but, in case of games, it invades the mind of the player making him become actively involved, controlling and driving him, placing him into a state of complete immersion. Immersion in the game is the state in which the player is available to learn thoroughly [9].

During the use of serious games in education, the student is the active subject of the learning process, he determines the pace of learning and his learning occurs because of interactions that he makes with the context of a problem proposed by the game, to build meanings that help him to solve it [10]. Therefore, the great advantage of serious games, in comparison to other educational resources is that, once the student receives the information, for his immediate use, there is a possibility that he can transform it into knowledge.

Other advantages of learning through serious games are:

- It can make learning fun, as its playfulness acts as a catalyst to acquire knowledge;
- Higher levels of concentration that the player tends to reach compared to other methods and;
- The ease to demonstrate through games how a specific topic can be applied to a practical context [11].

The fact that the students currently attending schools are considered "digital natives" favors the use of serious games in the classroom, but the introduction of serious games in the school life creates the need for the teacher and the school environment to be prepared to adapt their teaching techniques.

The pedagogical projects should incorporate naturally serious games as teaching tools and the teacher must be prepared to arouse students' interest and know how to lead them to a constructivist learning [3].

III. Challenges that Need to Be Faced While Designing Methodology

The course of development of serious games applied to education is part of a graduate course in computer science in a Brazilian university. In this course, there is a research laboratory of computer science applied to education. The course is a part of an effort to allow students from different cities outside the metropolitan area to attend classes. Aiming to broaden the access, the head of the program decided to offer some e-learning courses and amongst them was Development of Serious Games for application in Education, since there was high demand for it. Because of this, it was necessary to restructure the e-learning methodology to better suit this course. At first, the main challenges that had to be overcome were:

- How to teach an eminently practical e-learning course in order to generate the necessary learning for the students?
- How to enable the use of an assessment that also maximizes student learning without extrapolating the hours of discipline and without overloading the teacher?

The challenges increased when we analyzed the answers of a questionnaire previously sent to students interested in the discipline. This questionnaire aimed to scale the levels of knowledge and experience of students about video games, video games for use in education, video game development and online class/e-learning. The responses of 22 students showed that:

- Most of the students did not have a clear understanding on the difference between teaching and learning;
- There were many students who played video games only a few times in their lives, and there were those who were frequent players. The majority used to play at least once a week;
- The majority of the students had never developed any video games, but also there were students who specialized in developing video games;
- The vast majority of students thought that the only objective of video games was amusement. Further, that video games could be addictive or a waste of time, according to their parents and teachers' advices; and,
- Few students had the experience of participating in online classes of an e-learning course and they all considered the method less efficient than the traditional classroom.

Based on the answers, it was clear that the students of the class had a wide range of knowledge and experience on the topics to be addressed in the course and, in addition, the maturity of the students was diverse. The ages of the students ranged from 22 years to some with more than 50 years. There was also skepticism about the likelihood of success of an e-learning course in a subject that demands a lot of practice.

IV. Methodology Proposal

Based on the context reported in the previous section, it was decided to use an integrated approach in this course to support learning and learning assessment based on pedagogical architectures.

"The pedagogical architectures are learning structures made from the confluence of different components - pedagogical approach, educational software, internet, artificial intelligence, time and space conceptions (...) composing a craftsmanship, building on experiences of living and on the demands of action, interaction and reflection of the subject about the data, the objects and the socio-ecological environment. The assumptions of the curriculum in this regard, include open pedagogies to accommodate flexible, pliable, and adaptable teaching under different approaches" [12].

The pedagogical architectures help to think about the school and academic activities in an organized and systematic manner. They help to think about a competence, a skill or an

attitude that the student should develop (pedagogical objectives), to identify what pedagogical approaches (pedagogical strategies) can be applied to help him to develop the pedagogical objectives and, finally, what pedagogical tools (technological resources) can support the application of these strategies (Fig. 1).

Fig. 1. Pedagogical architecture

Despite its simplicity, this approach allows the teacher to choose the pedagogical approach that best suits the topics to be addressed in a specific course. Thus, it can also help to plan the activities (in and outside the classroom) supported by technological resources that will enhance these strategies in order to achieve maximum learning. The use of these pedagogical architectures allows not only a deeper and more consolidated learning but also a better use of hours spent on studies [13].

A. Pedagogical objectives for discipline

The first step in planning this course was to define its pedagogical objectives. Thus, they were divided into general and specific. The general ones comprise the development of skills and attitudes, important not only to the topics to be addressed in this course, but also for a computer science professional in general. The Fig.2 shows the general pedagogical objectives defined for this course:

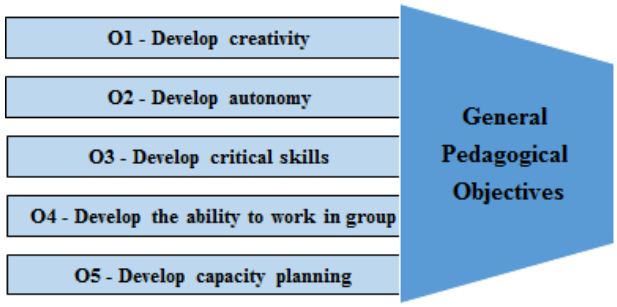

Fig. 2. General pedagogical objectives

The software developer, aiming at developing games, must be creative, in order develop games that are attractive to players, but he also needs to do its critical analysis, so that he can avoid mistakes, accept criticism and then build upon it [14,15]. Autonomy is another skill the professional must develop to be prepared to perform the activities that he will be responsible for. In addition, teamwork is also critical because developing games it is a multidisciplinary job, so he will be in working with others professional from areas such as computer science, music, animation, graphic design and marketing [16]. Finally, all the activities related to developing games must be well planned and monitored so that they can achieve better results, in less time and with less resources [17].

The specific pedagogical objectives contemplate the development of competence and skills for a serious games developer (Fig. 3).

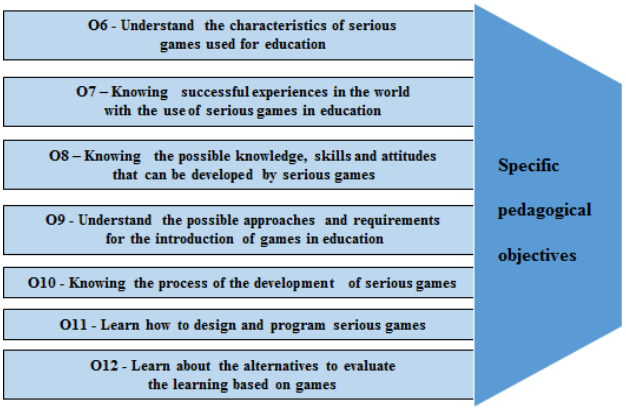

Fig. 3. Specific pedagogical objectives

Achieving these goals means that the student will be able to understand the importance of introducing serious games in classrooms, the context in which those will be introduced and the requirements which the serious games must address to be considered as fun. He also needs to be able to plan and develop serious games, besides understanding how the learning obtained through video games can be evaluated [2,6,7,8,14].

B. Pedagogical strategies for discipline

Next, for each pedagogical objective, we have planned one or more pedagogical strategies. In order to ease the planning, they were divided into general pedagogical strategies, pedagogical strategies to support learning and pedagogical strategies for learning assessment. The general pedagogical strategies are the baseline of how the learning environment should be. These are presented in Fig. 4.

In Figs. 4, 5 and 6, after the name of each pedagogical strategy, we can see the codes of the principal pedagogical objectives that the strategy was planned to support.

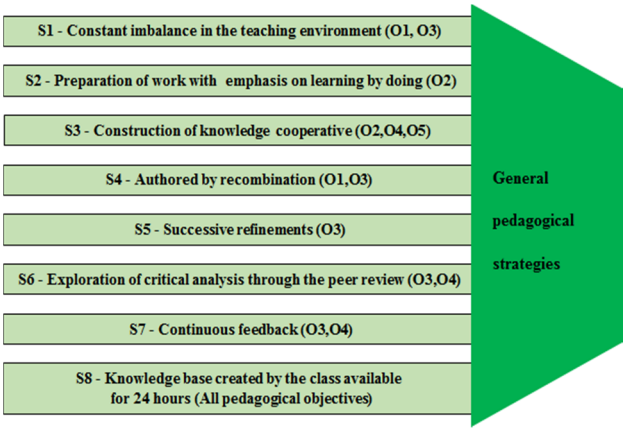

Fig. 4. General pedagogical strategies

Creativity and the ability to generate innovation are competencies that must be "in the blood" of the games

developer [18]. For students to be trained in these competencies it is necessary to keep the learning environment in constant imbalance, to question the validity and the merit of the solutions already developed, so that the students can go ahead and look for more creative or innovative solutions.

Considering that developing games is an activity that involves the domain of a process to achieve a final product, which basically is a software, the proposal was to use the strategy of learning by doing [19]. This approach allows the students to learn while they are immersed in solving a problem. Thus, the assumptions made to choose this approach were, all the students had previous knowledge in software engineering and they were able to build prototypes of serious games, using their experiences and completing the necessary information through: reading articles, using tutorial videos provided by the teacher, researches on other sources of information on the web and through the continuous exchange of knowledge with their peers. The concept of flipped classroom was also adopted, which consists of an instructional strategy and a type of blended learning that reverses the traditional learning environment by delivering instructional content, often online, outside the classroom. It moves the activities, including those that may have been traditionally considered homework, into the class. In a flipped classroom, students watch online lectures, collaborate in online discussions or carry out research at home and engage in concepts in the classroom with the guidance of a mentor [20].

The cooperative construction of knowledge was designed for the students to support "learning by doing" and develop their ability to work in groups [21].

The use of authorship by recombination of the solutions proposed by the students and the successive refinements of these solutions, aimed to teach them not to be satisfied with the first solutions they found but to move on looking for better solutions.

The use of peer reviews to evaluate the works produced by students and the use of continuous feedback in these analyses, allow each student to learn from what was criticized in his works and what he has observed in other peers' works [21, 22].

Finally, all the knowledge built should be registered on the web to facilitate the study at any time or any place.

The pedagogical strategies to support learning would be those aimed to support the learning of specific strategic objectives and should be guided by the general pedagogical strategies. The pedagogical strategies to support learning are shown in Fig.5.

Online classes were designed to anchor the other activities and were permeated by discussions on serious games and on the development of serious games. The fact that classes were online allowed the students from different locations to attend it, so there was a greater participation of the students.

The debate was also more intense than usual, since in classroom students tend to be more shy than online. In addition, because of the online nature of the classes, the presence of the teacher as a mediator provided more efficiency and effectiveness to the knowledge construction generated by the discussions [21].

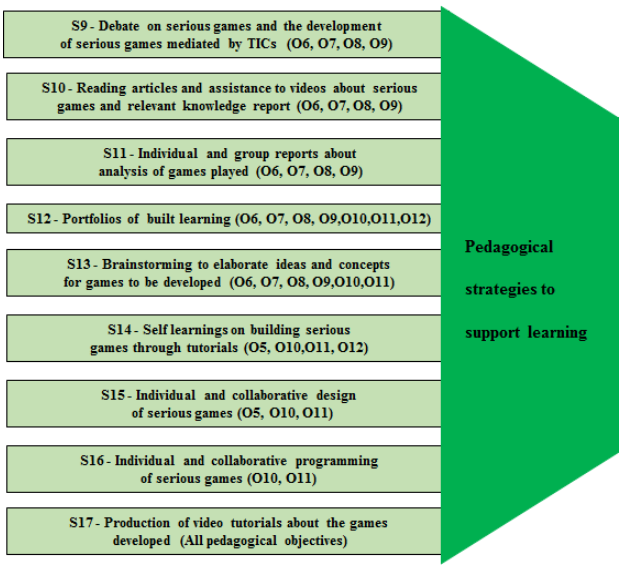

Fig. 5. Pedagogical strategies to support learning

Another important point is that communication planned preferably via chat could be recorded to create an important knowledge database for students.

To allow the students to know what has been researched and developed by the world, besides the points of view of the leading researchers on the subject, there was a proposition for a form where the student should record the most important parts after reading several papers, book chapters and viewing the videos available on the web. The records in the form would enhance the learning and help the students organize the knowledge obtained thereof. A standard online form was defined. This also would be available for peer reviews, in order to generate even more knowledge as described above.

It was also proposed that the students should play games individually or in groups. They can play older or modern games and after playing, they should report their analysis based on their experience, specifically about key features, the main resources, functionalities of the games and other aspects of the interface.

The learning portfolios would be the interface in which the students should register all their learning, as they took place. By registering their learnings in the portfolios, students could learn more by reflecting on what they learned and could better organize the knowledge built by themselves. Next, the portfolios would be accessed by the peers who should do critical analysis of its content, which enable the generation of new knowledge, and beyond this, the portfolios would help the teacher to evaluate their students continuously [18, 23,24].

Brainstorming is essentially a creative activity and it was expected to train students to generate ideas and concepts for the games to be developed [25].

Game developing either individually or in groups, using game engines was essential for students to learn practically how to perform the construction of serious games. The proposal was that the students should comply with the game development process completely and understand how: to create a concept for the game, to design a game, properly recorded in a Game Design Document - GDD, and to develop a prototype of a game. It was demanded for all students to build at least four games, two individual and two in groups of two to three. During the construction of the games, students should be incited to think in ways to assess the potential learning that players could gain by playing the games. To understand more about this subject, some of the students, who are interested in assessment of game-based learning, would receive some papers about the topic, and they would summarize their contents in a standard web form, which would be read by their peers.

The production of videos about games, that would be developed by the students, has also allowed them to realize a new way to think about what they have learned to organize their knowledge and to record their productions to be known by their peers that could generate new knowledge. By explaining the concept of their video games and how it was designed, students could learn even more.

The assumptions used to define the strategies for assessment were, the assessment strategies should contribute to maximize learning and they should not overload the teacher with a plenty of assessments to be evaluated later [18]. The pedagogical strategies for learning assessment are shown in Fig. 6.

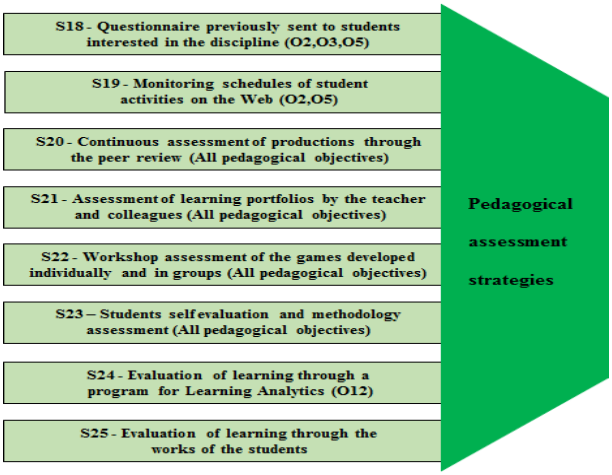

Fig. 6. Pedagogical assessment strategies

First, a system of self-monitoring was established to assess the delivery of the tasks performed by the students. Thus, a table to monitor the deliveries of the tasks was created and made available on the web, so that the students could fill it indicating the tasks he had completed, the time it was completed and links to the files related to their deliveries.

The peer review was also planned in a way to distribute the evaluation process, which was generally centered on the teacher, allowing him to plan a larger number of assessment activities, that otherwise would overload him [21]. The distributed evaluation would serve as another learning moment.

The evaluation of the learning portfolios, actually, would consist of three views: the student himself who wrote it, the peers who made their review and one review made by the teacher. When the student completes his portfolio he would actually be doing a self-reflective assessment of all he had learned. Then, peers would do their review and would point out the strengths and weaknesses of their peer's portfolio. By doing this, they could indicate to the student that his learning could have been better and therefore he should return to produce a new content. Finally, portfolios and comments from peer reviewers would be assessed by the teacher who would also point out the issues about the topics in which the student has not shown that he has developed the expected competencies [18,24].

The workshop is the moment that all the students could know the games and videos produced by their peers or other groups, prepare reports, take notes about what they learned, identifying the highlights about their peers' productions and the deficiencies so that they could be improved. Later, the teacher would assess the games and videos produced individually and in groups.

It was proposed that, in addition to the various assessments throughout the course, there would be a final moment in which all students would make a self-evaluation and also an evaluation of the teaching methodology. When the students would make these assessments, they could also learn a little more.

Finally, it could be requested to the students to think about a computational solution that would facilitate the teacher to evaluate their learning from the knowledge base to be built through the records of learning portfolios, messages recorded in chats and other electronic documents that were produced by the group.

V. A TECHNOLOGICAL FRAMEWORK TO SUPPORT THE METHODOLOGY

To develop a technological framework to support the pedagogical strategies, we take in account that:

- Classes will be held in the face modality mediated by communication tools using Internet [21];
- Communication should support discussions and also record them to make possible future queries by the students and the teacher [13,23];
- There should be a portal on the Web to store: a) presentation of the course syllabus; b) the meeting agendas; c) didactic materials to be used by the students such as, files, links to websites, videos and software; d) tracking the students´ works, and e) to post the students´ productions. This portal should also

be able to store: a) the comments and criticisms about each student's production, and b) the records about the online debates between the students and the teachers [13,18];

- Support to students´ collaborative work, using documents, spreadsheets, diagrams, games prototypes and others [18];
- To support the students to maintain a personal learning portfolio, to be reviewed by their peers and teachers [23,24];
- The technological tools and framework to support the course also needs to be free for educational use and easy learning.

The Fig.7 shows the technological framework conceived to support the planned pedagogical strategies.

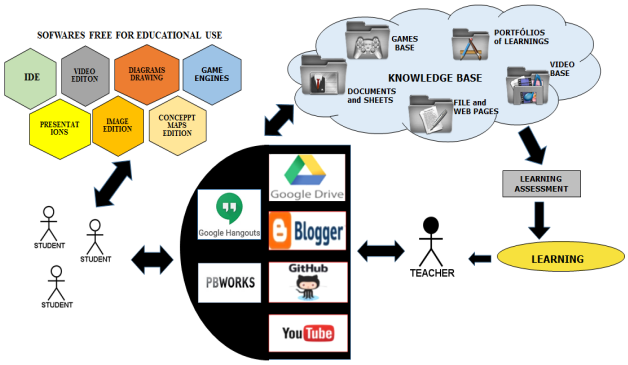

Fig. 7. Technological framework to support the methodology

The classes held in the face modality was planned to be supported, mainly, by Google Hangouts and by PBworks, a set of collaborative tools for site builders. The Hangouts would be used for conversations involving all participants and for conversation in small workgroups. With the Google Hangouts, it´s possible to record the conversations and thus makes it possible to retrieve them when needed.

The PBworks, which is easy to use and free for educational purposes, was chosen to build the portal of the course, in a collaborative manner by the students and the teacher.

All the technologies were chosen according to the planned pedagogical strategies. For example: Google Hangouts can support, mainly, the following pedagogical strategies: S1, S3, S7, S8, S9, S13 and S15; and PBworks can support, mainly, the following pedagogical strategies: S3, S4, S5, S6, S7, S8, S9, S10, S11, S15, S16, S18, S19, S20, S22, S23 and S25.

To produce documents and spreadsheets Google Docs and Google Sheets were chosen, which are well integrated with Google Hangouts. Their use is free, they were easy to use and, with them, the students would be able to work together in a same file, simultaneously. The files produced with them can be stored in the cloud services (Google Drive) or in memory device (hard disks).

For the repository of prototypes of videos and games to be produced by the students, YouTube and GitHub were chosen because they are well known and already widely used by the students enrolled in the course.

In order for the students to achieve acquaintance with the games, universe sessions of digital games immersion were realized. In these sessions different videogames were used, all of them with a good reputation in this branch, from the past such as Elifoot 2, Pac Man and Wumpus, as well as the video games, which have been great hits nowadays, such as School of Dragons and the Sim City. The main goal of exploration of these games was to help the students identify principles, characteristics and features of the games as well as the development that has occurred between these generations of games.

For the construction of the games successful game engines of the past were chosen such as Klik & Play, and also more modern game engines such as Construct 2 and Unity 3D were chosen in their free versions, which enable development of games with and without the use of programming.

In addition to this, a number of other softwares have been recommended for the preparation of videos, presentations, and diagrams. Among them, we can mention Emaze, Cantasia, Astah Community and the CmapTools.

For the students interested in building a computer program that would facilitate the teacher to evaluate student learning, the use of a development environment was planned which was comprised of Django and Python. The idea was to use this program to extract evidence of learning from the knowledge base to be built with the records of learning portfolios, messages recorded from Hangouts chats and other documents that were stored at the course portal.

VI. LEARNING AND RESULTS

Initially it can be seen that the course has brought good results through many productions made by the students, containing much knowledge built by them:

- 15 pdfs files with records from the classes held in the face modality , where each student posted an average of 21 messages per class, recorded in the portal of the course;
- 54 pdfs files with chat records of the discussions of the groups about the work in groups (2 to 3 students), where each student posted an average of 47 messages;
- 176 posts in the portfolios of learning, an average of 8 posts, 30 lines per student, all were visited and critically analyzed by, at least, two other students;
- 16 game prototypes were produced in groups, these prototypes were visited and criticized by the students of, at least, two other groups;
- Eight games were produced by groups and 22 games were produced individually, each with its GDD and with its video presentation posted on YouTube. These games were visited and criticized by their peers;

- Several other documents were posted by students on Google Docs, Google Sheet and PBworks such as, reports on games that were played, files, articles, reports on watched videos, reports on the characteristics of some game engines, etc.

Table 1 shows the assessment by 22 students about their level of satisfaction with their development, aspects of the course and the teacher's performance.

TABLE I. THE LEVEL OF ACHIEVEMENT OF PEDAGOGICAL OBJECTIVES EVALUATED BY THE STUDENTS

Evaluated Item	Evaluation by Students (%)			
	Excellent	High	Moderate	Low
Self development	64	36	0	0
Achievement of Pedagogical Objectives	95	5	0	0
Adequacy of Pedagogical Strategies	93	7	0	0
Adequacy of Technological Resources	90	10	0	0
Professor Performance	97	3	0	0

As it can be seen in Table 1 the students assessed positively about the adequacy of the pedagogical strategies employed and their teacher's orientation, but most of them thought that enough time was not allocated to: a) the learning outcomes related to planning for development of a game and, b) the analysis of the major game engines available.

Students indicated the highlights of the pedagogical strategies as: a) peer reviews of work combined with continuous feedback to the authors, and b) the cooperative construction of knowledge and the workshop for presentation of projects.

According to the majority of the students:

"... the reviews and feedback from peers were extremely important to determine the critical thinking, develop creativity and learn to work in groups. They were also the keys so that we could evolve quickly in the conception, design and construction of games".

Students also highlighted the strategy of collaborative knowledge building within both the Hangouts chats and group work. We can sum up the opinion of the students citing the following text:

"... the construction of knowledge occurred in a very fluid and fertile way through the presentations of theses, debates, presentations of antitheses to the theses presented, knowledge sharing, experiences and suggestions of ideas, which would be subsequently improved".

The workshop for the presentation of games that were developed individually or in groups also generated a lot of learning for students. To participate in the games workshop, the students had to perform various tasks: create a concept for a game, design a project for it, register the project in a GDD, build the game, prepare a video to present their game and provide basic instructions to use it. The workshop needed that each student had to "visit" the games of the peers, published in course portal, which implied: watch videos of the peers about their games, analyze the GDD of the games produced by them and, also play the games of their peers. After this, each student had to prepare a report of each visit and prepare such reports in the course portal of their peers. The makers of the games take them as reference to make corrections or improvements they judge necessary.

The students, and the professor, evaluated the games developed, using a checklist designed by themselves, under the supervision of the professor. The checklist contained criteria such as: ability to entertain, ability to challenge, usability, quality of graphic design and ability to generate learning. Based on the checklist the students found that 8% of games were of excellent quality, 80% of games developed were of good quality and only 12% were of moderate quality. Also based on the checklist, the evaluation of the same games by the teacher, considered 5% excellent, 75% good and only 15% of moderate quality.

It was clear to all students that the pedagogical strategies adopted were only feasible to be exploited to the maximum due to the framework of technological resources used to support them.

The use of online classes mediated by communication tools has proved its efficiency by the frequency of students, with 95% attendance considering all 15 meetings. Another important data is that only 4.5% of students´ homework were not delivered.

The selection of the Hangouts tool as a communication software, and to record the discussions that took place during the online classes was considered appropriate and efficient. This can be proved by the average number of messages posted by students per class (21 threads per student per class). Fig. 8 shows the teacher's view during an on-line class.

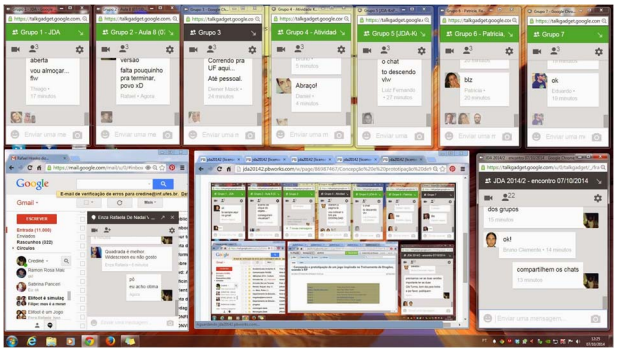

Fig 8. The teacher´s cockpit

It works as cockpit from where he can see all the debates in class between the members of the groups and between all the students in the large group. A single negative point in choosing the Hangouts was the limitation of ten simultaneous connections when we needed a video conference. This problem was solved by grouping the 22 students and teachers at 10 different facilities.

The PBworks was considered a very good service to produce the course portal because the web pages, files and links might contain the following contents: planning discipline, control of student attendance, control of the work produced by the students, records of the content presented by the teacher, the productions of the students, and all academics

articles, videos, software tools and tutorials required by the students to perform their works.

Google Docs and Google Sheet were also very helpful in enabling us to perform some pedagogical strategies through them, such as cooperative construction of stories for the games, brainstorming sessions, cooperative development of games project and voting options for game themes and issues in discussion.

GitHub, YouTube and Blogger fully meets the tasks set for them: storing videos, game codes and portfolios of learning.

The game engines and publishers of images, videos and presentations were freely chosen by the students, except for the game engine Klik and Play, which was recommended by the teachers as an introductory step for the students with such software. The most of the students chose to use free educational versions of Construct2 and Unity 3D. The majority of them related their experiments with the game engines as per the following text:

"The construction of a game using a game engine isn´t difficulty if we want a simple game. A teacher without any knowledge of programming can make it but if the game, that we pretend to develop is more complex, only a good programmer can make it using many interesting resources that are available in the game engines".

For the CmapTools software, as recommended by the teacher, it was very important for the students to articulate and consolidate the main concepts related to games.

Some students of the class who were interested in research about game-based learning assessment proposed a debate about "What would be the better way to evaluate game-based learning?" The majority of the participants of the discussions understood that the better way to evaluate game-based learning was to implement some functionalities in the video games that record data about situations that could represent learning, in a log file, during the game. Those situations could be: when the player won a challenge, answer questions, fulfill some task or phase of the game or hit some punctuation. Then, these records would be processed by a program that could analyze these results providing the teacher with an evaluation tool for game-based learning.

To understand a little more about evaluation of learning, some students also developed a prototype program to evaluate learning during their process of development of games from a database containing the archived messages in Hangouts, learning portfolios stored in Blogger and data files that were in PBworks. Some criteria have been set for the evaluation such as: the number of participating students in Hangouts chat, the size of your messages, number of suggestions that students posted to an issue called into question or a problem to be solved, number of posts in the portfolios of learning, size of posts, number of comments that each student made on posts of the peers in the portfolio and the number of posts that the students made in the ratings of the games that were posted on the course portal. The prototype program, although does not exhaust the possibilities of obtaining analyses of learning, from the records of student learning, enabled students to understand better what was learning process analytics.

VII. Conclusions and Future Work

The methodology based on the proposal of pedagogical architectures proved to be very efficient and effective for an eminently practical discipline as the game development. The methodology was not only great for planning the activities of the discipline, provided an efficient and effective implementation of this plan in addition to maximization of learning.

The framework of technological resources selected to support the methodology proved to be very satisfactory and enabled the enhancement of learning. The format of classroom lessons online in the flipped classroom format enabled a very active mediation by the teacher, intensified student participation and increased opportunities for cooperative construction of knowledge.

The adoption of a distributed mediation strategy where students reviewed the productions of their peers and, after that re-evaluated their own productions, allowed the teachers to propose further practical activities without overwhelming themselves after the evaluating the works of the students.

The evaluation of the games through a workshop was the moment when learning was maximized. The production of a game, individually and by groups and, also the production of videos by students presenting the development and the functioning of their games, provided the opportunity for the student to develop and demonstrate everything he learned in the course. The quality of the games produced, according to the checklist used to assess them, clearly showed that all the students performed good learning during the course.

The proposal of some students about how to evaluate game-based learning and the development of prototype of a program that could obtain evidences of learning based on the data in the learning portfolio, the course portal and the records with the messages of Hangouts, gave the students a good view of the necessity to implement tools for learning assessment, including game-based learning assessment.

As the first future work, we intend to evaluate the methodology and the framework in a class with more students than that one related in this work. Another work for the future is to include in the program of the discipline a subject about the development of learning analytics tools for learning game-based assessment [26]. The expansion of the use of serious games in education has been hampered due to few consolidated resources, and easy of use by teachers, to verify learning obtained by these games. Therefore it can be a good field of research for the students.

REFERENCES

[1] M. Prensky, Digital game-based learning, St. Paul, MN: Paragon house, 2007.

[2] D. Ifenthaler, D. Eseryel, and X. Ge, Assessment for game-based learning, New York: Springer, 2012, pp. 1-8.

[3] J.P. Gee, "Good Video Games + Good Learning," in: Peter Lang International Academic Publishers, 1st edition, Nova York, 2007.

[4] M. Ma, "Introduction to serious games development and applications," Entertainment Computing 2.2, 2011,pp. 59-60.

[5] P. Moreno-Ger, I. Martinez-Ortiz, M. Freire, B. Manero, and B. Fernandez-Manjon, "Serious games: A journey from research to application,", In Frontiers in Education Conference (FIE), 2014, pp. 1-4.

[6] P. Moreno-Ger, D. Burgos, I. Martínez-Ortiz, J. L. Sierra, and B. Fernández-Manjón, "Educational game design for online education," Computers in Human Behavior 24, no. 6, 2008, pp. 2530-2540.

[7] M. Kebritchi, "Examining the pedagogical foundations of modern educational computer games," Computers & Education 51.4, 2008, pp.1729-1743.

[8] M. McGill, "Critical skills for game developers: an analysis of skills sought by industry," In proceedings of the 2008 conference on future play: Research, play, share, ACM, 2008, pp. 89-96.

[9] D. Weibel and B. Wissmath, "Immersion in computer games: The role of spatial presence and flow", International Journal of Computer Games Technology, 2011, p. 6.

[10] V. Shute, M. Ventura, Y. J. Kim and L. Wang, Assessing Learning in Video Games, chp. 10, pp. 1-10.

[11] H. Mouaheb, A. Fahli, M. Moussetad, and S, Eljamali, "The serious game: what educational benefits?", Procedia-Social and Behavioral Sciences, n. 46, 2012, pp.5502-5508.

[12] M.J.S. Carvalho, R.A. de Nevado and C.S. de Menezes, "Arquiteturas pedagógicas para educação à distância: concepções e suporte telemático", In Proceedings of XVI Simpósio Brasileiro de Informática na Educação, Juiz de Fora - MG, Brasil, 2005.

[13] C. Coll and C. Monereo, Psicologia da Educação Virtual: Aprender e ensinas com as tecnologias da informação e da comunicação, Artmed Editora, 2010. ch.15.

[14] C. Crawford, The Art Of Computer Game Design: Reflections Of A Master Game Designer, McGraw-Hill/Osborne Media, 1984.

[15] R. Koster, Theory of fun for game design, O'Reilly Media, Inc., 2013.

[16] B.R. Maxim and B. Ridgway, "Use of Interdisciplinary Teams in Game Development", In Proceedings of Frontiers in Education Conference, Milwaukee, WI, 2007.

[17] E. Adams, Fundamentals of Game Design, Pearson Education, New Riders, 2nd edition, 2010.

[18] A.P. Gómez, Educarse en la era digital, Madrid: Morata, 2012.

[19] R.C. Schank, T. R. Berman and K. A. Macpherson, Learning by doing. Instructional-design theories and models: A new paradigm of instructional theory - vol 2, New York: Routledge, 2009, pp. 161-181.

[20] J.L. Bishop and M. A, Verleger, "The flipped classroom: A survey of the research," In ASEE National Conference Proceedings, Atlanta, GA, 2013.

[21] R.M. Palloff and K. Pratt, The excellent online instructor: Strategies for professional development, John Wiley & Sons, 2011.

[22] J. Hattie and H. Timperley, "The power of feedback," Review of Educational Research, n.77, 2007, pp.81-112.

[23] R. Aragon, C.S. Menezes, S.Z. Novak, and M.K. Lenz, Aprendizagem em Rede na Educação à Distância: Práticas e Reflexões; Evangraf, 2014.

[24] G. D. Chen, C.C. Liu, K.L. Ou and M. S. Lin, "Web learning portfolios: A tool for supporting performance awareness," Innovations in Education and Teaching International 38 no. 1, 2001, pp.19-30.

[25] L.A. Liikkanen, K. Kuikkaniemi, P. Lievonen, and P. Ojala, "Next step in electronic brainstorming: collaborative creativity with the web," In CHI'11 Extended Abstracts on Human Factors in Computing Systems, ACM, 2011, pp. 2029-2034.

[26] B.K. Baradwaj and S. Pal, "Mining educational data to analyze students' performance", arXiv preprint arXiv:1201.3417, 2012.