Design Guidelines for Classroom Multiplayer Presentational Games (CMPG)

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Abstract
In a Classroom Multiplayer Presentational Game (CMPG) peers interact collaboratively with the virtual world and amongst themselves in a shared space. The design of this kind of game, however, is a complex process that must consider instruction strategies, methodology, usability and ludic aspects. This article’s aim is to develop and systematize guidelines for the design of CMPGs. To develop these guidelines we used a three-step process: evaluating an initial implementation of a CMPG and finding its problems; defining guidelines that can help overcome these problems; and redesigning the game based on the guidelines before testing it in a real class scenario to assess how helpful the guidelines were in solving the initial problems.

From the initial evaluation of the game, we developed a series of guidelines to overcome the existing problems that can be classified into six categories: On-screen information, Game mechanics, Game progression, Methodology, Collaboration, and Holism. After redesigning the game with these guidelines we performed a field study to see the behavior of the new CMPG; where we measured how well the guidelines were applied in the game-play and the effectiveness in regard to the learning level reached by the students. Our results indicate that the guidelines are a valuable tool in the design of CMPGs that foster learning, which was shown both in the results of the observations and in the significant increase in learning. Although the design guidelines can be seen as general principles, we conclude that they have to be considered differently for different games, and that even during a specific game the importance of each guideline may vary throughout the different quests.

1. Introduction
Videogames present many possibilities for developing knowledge and improve teaching and learning practices in schools, especially those of a collaborative and cooperative nature (El-Nasr, Aghabeigi, Milam, Erfani, Lameman, Maygoli, & Mah, 2010). Within their broad potential, what stands out the most is: increasing students’ interest in learning, adapting to the user’s tempo, improving and strengthening the acquisition of information and awakening and maintaining motivation (May, 2009).

As Amory (2007) points out, designing videogames for education implies integrating instruction strategies and ludic activities, in benefit of certain educational
goals. The absence of this integration is one of the factors that inhibit the use of videogames in the classroom (Baek, 2008). Instruction strategies refer to the development of methods that make the curriculum operative within the context of the game, favoring learning (Serin, Serin, & Saygılı, 2009). On the other hand, ludic dynamics refer to the mechanics of the game and a relation to the players that assures motivation and playability (Fabricatore, Nussbaum, & Rosas, 2002). There is also a correlation between videogames design patterns and the development of cooperative relationships among players (El-Nasr, et al., 2010).

When linked to new teaching practices, videogames improve educational achievements in students that are usually excluded by traditional teaching methods (Virvou, Katsionis, & Manos, 2005). In particular, Massive Multiplayer Online Games - (MMOGs) develop a type of technology that increases interactivity and participation in the virtual worlds offered to the user. This is explained by these games’ specific characteristics: the design of a fantastic atmosphere that favors the participant’s immersion, interactivity among participants through the virtual world, and a story and script structured around challenges that develop critical thinking, teamwork and strategies for problem solving (Dickey, 2007).

In MMOGs each player actively participates in the game from their own individual computer, connecting online with other players, with an administrator who is in charge of organizing the rules and making sure the game is playable. Since the rules, objectives, accessories and tools of the game are built by the designers (Zagal, Nussbaum & Rosas, 2000), this active participation could encourage learning the rules of a specific area of scientific knowledge (Gee, 2005). The use of games has an important educational potential, both in and out of the classroom.

Within the classroom, videogames could be the answer to the education community’s concerns. For teachers, they could become a valuable tool that incorporates collaborative work and technology (Alvarez, 2006). Videogames can be used to cover certain points in the curriculum, but they must be designed so as to maintain the fundamental characteristics of the act of playing: freedom to explore, freedom to make mistakes, freedom to experiment, and the possibility of building an identity (Osterweil & Klopfer, 2009).

Efforts to bring videogame computer technology to the concrete experiences of the classroom have not been particularly successful. Many educational videogames are not engaging. They don’t incorporate fun into learning, resulting in repetitive, poorly designed tasks that don’t help students’ progressive comprehension (Kirriemuir & McFarlane, 2004) and are centered on simple “drill and practice” models (Squire, 2003). Others get stuck on “edutainment”, meaning focusing on the ludic aspect, and don’t challenge students to develop hypotheses or problem solving strategies (Sancho, Fuentes-Fernandez, Gómez-Martín, & Fernandez-Manjón, 2009). The implementation of design guides that incorporate the requirements of both education and videogame design is still
In order to take advantage of the great interactive, motivational and participatory potential of MMOGs, we have studied how to incorporate them into the classroom (Susaeta et al., 2010; Nussbaum et al., 2009). In our setup, the game is carried out on a screen which is projected at the front of the classroom, through which the students interact with the virtual world and amongst themselves in the shared space (Figure 1). Each player has his own input device, which allows him or her to control his or her character within the game. Because the players are inside the classroom, we replaced the word “Massive” for “Classroom”, and because they are all present in the same physical space, interacting in person, we substituted “Online” for “Presential”, thus obtaining Classroom Multiplayer Presential Game (CMPG), where there is a link between the mechanics of the game and the teaching process. Just as there is a game master in MMOGs, in CMPGs the teacher plays the role of game mediator, with the educational contents laid out in the virtual world, as well as in the direct interaction amongst students.

![Figure 1](image.png)

Figure 1: Position of the screen and participants inside the classroom.

This article’s objective is to develop and systematize guidelines for the design of CMPGs that support teaching activities linked to curriculum contents in the classroom. To devise these guidelines we developed a three-step process. First, we evaluated a previous implementation of a CMPG to teach the concept of the food chain to 6th grade students, to detect its problems and weaknesses (section 2). Second, based on the problems detected, we used existing literature in educational game development, educational
multimedia activities and commercial game design to define a series of guidelines aimed to solve these problems (section 3). In the third and final step, we applied these guidelines to redesign the CMPG and tested the new version of the game with a group of students, analyzing how useful the guidelines were in designing the new version of the game (section 4).

2. Building a CMPG to teach the food chain to 6th grade students

2.1 Description of the game

The use of computer technology in the classroom has proven to be effective in achieving motivation (Ke, 2008b), collaboration (Cortez, Nussbaum, Woywood & Aravena, 2009) and learning results (Zurita, Nussbaum, & Shaples, 2003; Carbonaro et al., 2008; Plass et al., 2010a). Two kinds of educational objectives can be reached: transverse, pertaining to the development of an ethic conscience, personal self-affirmation and coexistence with others; and vertical, pertaining to the progressive grasp on the contents of the school curriculum (Ministerio de Educación [Mineduc], 2002).

The CMPG to teach the concept of the food chain (Susaeta et al., 2010) was included in the ecology curriculum unit. The game uses interactivity and immersion to boost the achievement of transverse and vertical goals in the school curriculum at 6th grade level (Mineduc, 2004). The specific objectives and expected learning outcomes of the game are shown in table 1. The game was designed for ten concurrent players because this was experimentally shown to be the maximum number of avatars that can simultaneously play on one conventional screen (1.5m x 1.5m) (Susaeta et al., 2010).

<table>
<thead>
<tr>
<th>Vertical teaching objectives</th>
<th>Transversal teaching objectives</th>
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<tbody>
<tr>
<td>To describe and comprehend the processes of flow and exchange of material and energy between living beings in a hypothetical ecosystem.</td>
<td>To promote collaboration, responsibility and personal autonomy.</td>
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<td>To use knowledge and be able to select relevant information.</td>
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<td>To promote initiative and teamwork</td>
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Table 1. Teaching objectives of the ecology game.

The ecology game includes a number of different quests following the CMPG model (Echeverría et al., 2011), each one designed to emphasize a key teaching objective. They are arranged linearly so that the end of one marks the beginning of the next. This order is determined by the curriculum structure set by the Chilean Ministry of Education and ensures that the course concepts are delivered incrementally.

Students participated in the virtual world after choosing a character with specific abilities: “Shaman”, with the ability to cure diseases and plant seeds, or “Hunter”, with the
ability to hunt. Students controlled their character by using the left and right buttons (one mouse per student).

Three of the game’s quests are aimed at achieving specific vertical objectives (Table 1). In the first quest, a new foreign species joins the ecosystem. This new predator starts feeding on the predators that were previously at the top of the food chain, transforming the ecosystem. The players must protect the ecosystem by scaring away the new species; to do this they must approach the new predator species in groups of no less than three players so as to lead it away from the playing zone.

In the second quest, a strange parasite starts to affect all the animals and it turns into an epidemic. The players have to contain this epidemic. To do this, two roles are defined in the game: the hunter, who paralyses the infected animal, and the Shaman, who later cures it.

In the third quest, there is an explosive reproduction of the herbivorous population, becoming a risk to plant life. In the virtual setting, the plant ecosystem comprises three areas and its existence is at risk from this increase in herbivorous predators. The players must work together to prevent these herbivores from destroying the ecosystem by killing off plants in each one of these three zones. The players must plant more plants, kill the herbivores when they become too numerous and ensure that there are always carnivorous predators in each zone.

The game is used as a supporting tool by the teacher to conduct the class, who is in charge of the computer which was running the game. As the students advance in the game, the teacher can pause the game-play and use the whiteboard to explain a specific concept about the ecological balance that was observed in the game. The teacher also fulfills the role of mediator in the discussions between the students, relating the strategy to solve each quest and by guiding the students, when necessary, according to the teaching objectives.

### 2.2 Problems detected

The results of a first, exploratory, study (Susaeta et al., 2010) showed that the CMPG favored the achievement of vertical goals in students, improving the learning results of content relating to the food chain through the application of the corresponding contents to the virtual world offered by the game. With regard to transverse goals, promotion of responsibility, autonomy, reflection, and teamwork could be observed in students.

The methodology used to analyze the player’s experience with the game included both ethnographic observations during the game session and discussion with the students after the game was played. The qualitative observations were gathered by two researchers.
through the different quests of the game, and they were classified into two types: individual work and collaborative work observations. The individual work observations were focused on two dimensions: identification of elements in the game and activity understanding. The collaborative work observations were focused on four dimensions: exchange of information between players, negotiation, leadership and coordination.

The results of the observations made during the game session and the discussion with the students showed that the experience was not without difficulties, and that many aspects of the game could be improved. A careful review of this initial experimental study allowed us to identify a series of specific problems and weaknesses in the game:

1. **Lack of feedback and guidance**: There is feedback at the end of the quest, but not during the process. Because of this, players cannot tell which actions – whether individual or collective - are best for solving the activity. Players tend to forget, or mistake, their character’s abilities, lessening on-screen participation.

2. **Unclear relation between game actions and learning content**: Players lose the quests because they don’t understand the interdependence between the elements of the food chain.

3. **Unclear and weak narrative**: The game’s activities are not sustained, or don’t develop the motivational potential of the narrative.

4. **Too many concepts presented simultaneously**: Quests cover several food chain concepts simultaneously. This adds fantasy to the game, but makes the didactic presentation of the food chain difficult. Quest resolution demands collaborative actions with different levels of difficulty to be carried out.

5. **The teacher role in the game was not clearly defined**: The absence of predefined criteria and guiding questions to support the teacher’s role diminishes student participation.

6. **Lack of face to face interaction**: Players understand the quests and the fact that the solution requires direct dialogue between them. However, the game does not offer enough favorable conditions for a collaborative dialogue.

7. **Lack of collaborative game mechanics**: The learning of transverse goals was affected by the absence of collaborative mechanisms to be discovered in the game. Players with better videogame abilities may lose interest in a virtual world where they have nothing new to discover.
8. **Poor use of screen space:** At the beginning of the game, the characters and events are located on certain parts of the screen. This generates grouping and space misuse, creating confusion.

9. **Unrecognizable elements:** Participants mistake their characters during the game. The interaction between characters and the screen elements is not evident.

10. **Inaccessible language:** During the activity, students don’t read the instructions on the screen. Texts are too long, and there are parallel activities on screen.

11. **Information overload:** The individual information surrounding each character confuses players when they interact.

12. **Lack of coordination between all the aspects of the game:** The ludic, instructional and collaborative dimensions of the game were not explicitly coordinated. This affected the integral comprehension of the game as a whole.

### 3. Guidelines for the design of a CMPG

For each of the problems described in section 2.2, we propose a design guideline that helps to solve the specific difficulties associated with the problem. The guidelines we present in this section for the development of CMPGs consider two contributing factors: instruction strategies and game elements (Amory, 2007). The design guidelines are grouped in six categories: game mechanics, game progression, methodology, collaboration, on-screen information and holism.

#### 3.1 Game mechanics

Game mechanics for learning describe patterns of behavior through which learners/players interact with and learn from the game, and are designed in pursuit of optimal insertion into a classroom context. In this sense, game mechanics guidelines answer the question: how should the game be played?

1. **Interactivity and guidance**

Considering that unguided discovery does not work, Domagk, Schwartz, and Plass (2010) propose a model for interactive multimedia learning, i.e. learning activities where the students interact using multiple media (visual, audio, etc.), an example of which are educational games. This model observes that interactivity refers to reciprocal activities among the action possibilities offered by the multimedia system, where action, motivation, and the student’s cognitive processes are oriented towards achieving learning. Consequently, designing an educational game requires interactivity guides to orient the
student’s actions, which implies concepts such as feedback, notices and action suggestions that are specific to each student (Domagk, Schwartz, & Plass, 2010).

Feedback is inherent in videogames; it maintains participation, and informs players of their achievement level (Aldinger, Kopf, Scheele & Effelsberg, 2005; Ang et al., 2008; Moreno-Ger et al., 2008). If the game feedback is delivered in a constant manner throughout the game it can also work as reinforcement to participants’ partial achievements (Osterweil & Klopfer, 2009).

In collaborative games it is important to differentiate between two types of feedback: individual feedback, which is targeted to each individual player, and collective feedback, which is targeted to all the players, or a subgroup of players. Individual feedback promotes the experience of a role within the game (Lim, 2008), while collective feedback orients interaction between participants (Lim, 2008; Sancho et al., 2009). Feedback to individual and collective action is efficient when it is coherent with the game’s design for the flow of activities (Dillenbourg, 2002). In other words, an appropriate design, which promotes learning, is achieved with precise, timely, and constant information regarding success and failure in the participants’ performance (Rosas et al., 2003).

Based on this literature review, we propose the following guideline regarding feedback in classroom games:

- The game must offer guidance, both for individual and collective action, through precise, timely and constant information regarding success and failure in performance.

The elements that favor interactivity are related to: participants’ previous experience in the use of videogames (Orvis, Horn, & Belanich, 2008); students’ motivation in having a concrete tool to participate in the events being carried out on screen (Infante, Hidalgo, Nussbaum, & Alarcón, 2009); the game’s complexity taking into account the users’ level of expertise (Sundar, Xu, & Bellur, 2010); and the teacher’s development of class activities where he integrates teaching content with the students’ participation in the videogame (Wilson, 2009).

These elements allow us to propose another guideline relating the kind of interaction players should have in classroom games:

- The user’s interaction with the game must be simple and intuitive and not add unnecessary complexity to the game.

Examples of commercial video games that correctly satisfy these guidelines are “World of Warcraft” (Blizzard Entertainment, 2004), “Diablo Series” (Blizzard Entertainment, 1996) and “Metal Gear Series” (Konami, 1990).
2. Mechanics linked to learning objectives

It isn’t enough to build a good game and add questions about certain content (Osterweil & Klopfer, 2009); it is fundamental that, through action and interaction in the context of the game, said content must be reinforced. The connection between ludic and instructional aspects of the game must be present throughout the duration. This promotes aspects such as attention, trust, satisfaction and discerning what is relevant, all of which characterize the intrinsic motivation linked to elements of the instructional or curricular process that the game covers (Cheng & Yeh, 2009). In this sense, the game presents itself, from beginning to end, as a situation that is uncovered through interactive action (Osterweil & Klopfer, 2009).

The importance of the intrinsic motivation provided by videogames lies in the stimulation of participants towards choosing tasks, regardless of their level of difficulty (Orvis et al., 2008); which presents an opportunity to create new learning strategies through quests (Dickey, 2007). There is great educational potential in living the events of a story through the game, since it leads participants to make decisions and understand complex phenomena (Aldinger et al., 2005) as well as triggering a metacognitive awareness of the learning process (Ke, 2008b). The interface must inform players of their options, integrating both curricular and ludic elements (Amory, 2007).

As is said by Gee (2005), good games present activities that are feasible yet challenging, thus ensuring that the frustration of potential failure does not take away from the pleasure of participating in the activity. The combination of teaching contents with the participants’ direct experience favors learning based on problem resolution (Sancho et al., 2009) and the structured interaction between participants through a design that centers on educational objectives (Dillenbourg, 2002). In the same way, it allows the determining of class activities and contents that are to be evaluated (Cox & Marshall, 2007).

Based on this literature review, we propose the following guideline that links the game mechanics with the educational objectives:

- The curricular content must be embedded in the game’s functioning mechanics in such a way that the game’s success is conditional to understanding its content.

Examples of commercial video games that correctly satisfy these guidelines are “Age of Empires Series” (Microsoft, 1997), “Total War Series” (The Creative Assembly, 2000) and “Civilization Series” (Sid Meiers, 1991).
3.2 Game progression

These are guidelines that indicate how the game should evolve, as the players progress, considering mechanical, narrative and curricular aspects. Game progression guidelines answer the question: how should the game evolve?

3. Clear narrative

Games should be linked to a narrative or literary script that gives continuity to its activities. The narrative organizes and defines activities in a sequential and precise pattern, where the interface elements are joined as a whole, promoting immersion (Amory, 2007). It should be made up of quests and challenges in such a way that by solving them, the game is solved in a logical chain of events (Dickey, 2006; Lim, 2008), and that favor the participants’ commitment to the different path the game proposes (Dickey, 2007). The clarity of the narrative sequence allows the construction of hypotheses and strategies, and also gives contextual meaning to the elements of the virtual world (Gee, 2005), thus helping to synchronize actions between players (Zagal et al., 2000).

Based on these elements, we propose a guideline that characterizes the narrative of classroom games:

- The narrative should be composed of quests and challenges that define collaborative activities in a sequential and precise pattern.

The narrative flow incorporates participants’ actions in the game and affects future actions (Martínez-Ortiz, Moreno-Ger, Sierra, & Fernández-Manjón, 2008). In this sense, the narrative should be linked to the achievement of instructional goals because this helps predefine possible actions in the narrative flow, as well as determining how long the game will last (Aldinger et al., 2005). On the other hand, the narrative structure must preserve the interactivity inherent in videogames in order to guarantee entertainment and learning (Moreno-Ger et al., 2008). It is important for the design structure of the game to have a base story that allows participant immersion, elements of intrigue and emotional closeness which, as a whole, promote progressive interest in the activity (Orvis et al., 2008). A compelling narrative can provide an external motivation that the materials themselves may not be able to provide.

The role of the story in classroom games can be summarized in the following guideline:

- The game must have a base story that allows the participants’ immersion.

Examples of commercial video games that correctly satisfy these guidelines are “Final Fantasy Series” (Square Co., 2001) and “Baldur’s Gate Series” (Bioware, 1998).

4. Gradual increase in difficulty
In education, teaching contents are organized into goals that favor students’ gradual learning, which implies organizing learning activities in an ascending order of cognitive complexity (Anderson et al., 2001). In this sense, the educational videogame must have a script with a complexity structure associated to instructional strategies (Dillenbourg, 2002). This allows the definition of situations with different and progressive levels of difficulty, which maintain students’ motivation to develop a certain ability or knowledge (Pirainen-Marsh & Tainio, 2009; Infante & Nussbaum, 2010).

The importance of a script can be summarized in the following guideline:

- The videogame must have a script with a complexity structure associated to instructional strategies.

Educational videogames use fantasy and entertainment as resources to develop problem solving hypotheses and strategies (Sancho et al., 2009; Rosas et al., 2003). The gradual increase in difficulty is expressed through the flow: challenge, puzzlement, and search offered by games to participants; promoting learning through the movement of abilities and knowledge (Amory, 2007), and which can be controlled by built-in assessment (Moreno & Mayer, 2010).

The link between game progression and learning progression is summarized in the following guideline:

- The learning progression needs to be reflected by the instructional strategy and the difficulty progression in the game.

Examples of commercial video games that correctly satisfy these guidelines are “Neverwinter Knights” (Bioware, 2002) and “Resident Evil Series” (Capcom, 1996).

### 3.3 Methodology

This category covers the instructional aspects of class organization and guides the teacher’s actions as game mediator. The methodology-related guidelines answer the question: how does the game help the instructional strategy?

5. **The teacher is a mediator during the game**

The teacher must ensure that the game helps his/her instructional strategy. Videogames are an element that favor the “teacher effect” in students’ learning (Annetta, Minogue, Holmes, & Cheng, 2009). The teacher leads the educational process in the classroom and is in charge of filling the gaps that exist between the students and the game, promoting discussion and reflection on contents (Moreno-Ger et al., 2008). This means that the game’s design must have a flexible structure that allows the teacher to guide the flow of the game to specific situations in the classroom (Aldinger et al., 2005; Wilson, 2009; Infante & Nussbaum, 2010), thus enriching his/her teaching practice (Cuban, Kirkpatrick & Peck, 2001).
When taking charge of integrating the instructional activity with the elements of the game, the teacher can design methods that include his/her students' variety of interests and cognitive needs (Virvou et al., 2005; Cox & Marshall, 2007; Infante & Nussbaum, 2010) that are relevant to the classroom context, through face to face interaction, which the structure of an isolated script cannot offer (Dillenbourg, 2002). In this sense, videogames do not guarantee learning unless they have the teacher as a main guide to the students’ cognitive development (Ke, 2008a).

Based on this literature analysis, we propose a guideline to define how to design games according to the teacher’s needs:

- The game’s design must have a flexible structure that enables the teacher, who is the game moderator and guides the flow of actions, to adjust the game to the actual participation of the students in the classroom.

Examples of commercial video games where these guidelines appear explicitly are those games that have a Game Master, which mediates between the game and the players, for example “Dungeons and Dragons” (Wizards of the coast, 1997).

3.4 Collaboration

This category refers to interaction, both amongst participants, and between participants and the game. The use of the CMPG diversifies communication channels between the teacher and his/her students, as well as those among the students, to collaboratively solve the quests presented by the game. The guidelines of this category answer the question: how can teamwork between the game’s participants be improved?

6. Organize face to face interaction

Face to face interaction is an everyday occurrence in the classroom, but its educational value has yet to be considered in traditional teaching methods. The use of technological resources allows students to have more options for participation and interaction (Gee, 2005). It is possible to incorporate face to face interaction into the design of game scripts (Dillenbourg, 2002). By combining technological resources with content transmission and dialogue amongst students, collaboration is promoted (Wilson, 2009; Susaeta et al., 2009), as is the case with simulation games that encourage the student to have a perspective of the game that considers other points of view (Chen, Lien, Annetta, & Lu, 2010).

In this sense, the game must allow face to face interaction between players, so that collaboration can happen. Although videogames don’t replace the communicational richness of face to face interaction (Dillenbourg, 2002; Sancho et al., 2009), they generate conditions that allow it to take place, without restricting the students’ movement within
the classroom (Cortez et al., 2009), and even favoring direct participation of students on a single screen, through individual input devices (mouse) (Infante et al., 2009; Susaeta et al., 2009).

The back story and scene cuts in the game favor the teacher’s mediation to promote direct communication amongst students (Dickey, 2006) in order to solve quests, where dialogue, as well as design and application of strategies, are key to the learning activity (Lim, 2008). The results of participation in the videogame, for example in simulated participation, guide the face- to- face dialogue that allows learning to take place (Delwiche, 2006; Wilson, 2009). Computer technology can structure the dialogue in the classroom, to promote the making of collaborative decisions (Cortez et al, 2009; Infante et al., 2009).

The previous analysis results in the following proposed guideline:

- The game must use elements such as the underlying story and scene cuts to favor the teacher’s mediation and promote communication between students.

7. Mechanics linked to collaboration

Videogames promote and offer new resources for collaboration amongst students for a number of means: developing narrative abilities through the interactive construction of stories (Carbonaro et al., 2008); experiencing a role through which they can interact in the virtual world in order to achieve a certain goal (Aldinger et al., 2005); developing the practice of argumentative dialogue through the use of digital resources (Ravenscroft, 2007); and applying the information needed to solve a task in coordination with their peers (Hamalainen, 2008). The videogame can adapt to the students’ different learning rhythms, because it offers an environment of dialogue with the game and among students (Virvou et al, 2005).

In educational videogames, the structure of the game must be related to the collaborative instructional strategy in a way that offers enough elements to stimulate fantasy, exploration and teamwork amongst players (Gee, 2005; Amory, 2007). Designing puzzles with a common goal for all players promotes the development of strategies and helpful relationships (El-Nasr, Aghabeigi, Milam, Erfani, Lameman, Maygoli, & Mah, 2010). An unnecessarily complex interface, with unfamiliar participation tools, reduces the game’s accessibility (Delwiche, 2006).

A complementary element that adds to the collaborative mechanics in each step of the game is the action guide, where the different collaborative options that allow students to solve the problem at hand are specified (Dillenbourg, 2002), thus promoting autonomy and individual responsibility in teamwork throughout the activity.

Regarding collaboration and games, we propose the following guideline:
Collaboration must be embedded in the game’s functioning mechanics, so that its success is conditional to having worked collaboratively.

3.5 On-screen information

Considering that the interface in computer mediums diversifies the users’ interactivity and learning experience, (Sundar, Xu, & Bellur, 2010) in this section we considered guidelines that show how to display all the elements of the game in such a way as to reduce the students’ cognitive load. The guidelines associated with this category respond to the question: how should the game look?

8. Adequate spatial distribution

Adequate spatial distribution means presenting static and dynamic elements onscreen in such a way as to favor interactivity, meaning reciprocal actions between the student and the multimedia system (Domagk, Schwartz, & Plass, 2010). Videogames have evolved from simple two-dimensional games to advanced multiplayer three-dimensional experiences, thus better capturing the students’ attention and allowing for more exploration of the virtual world (Lim, 2008). At the same time, the number of elements that exist in the virtual world has increased, making their correct placement more complex. In this sense, an appropriate stage design or distribution of elements on the screen favors aspects such as: playability (Fabricatore, Nussbaum, & Rosas, 2002), immersion (Dede, 2009), and the interaction between elements in the virtual world and its connection to the real world (Hinske, Langheinrich, & Lampe, 2008). It also complements verbal communication, favoring conversation that is functional to the activity, cooperation between players (Greiffenhagen & Watson, 2009), and the construction of individual knowledge sustained by collaboration (Looi & Chen, 2010).

Based on this analysis of spatial distribution, we propose two guidelines:

- The system must distribute characters and activities around the map so as to take advantage of the available space.
- Spatial distribution should correctly relate aspects of the embedded knowledge to its connection with the real world.

In difference to Massive Multiplayer Online Games (MMOGs), where each user begins the activity in the center of his individual screen (Delwiche, 2006), in CMPGs all participants share the same screen (Susaeta et al., 2009), making it necessary to use a stage design that uses the available space appropriately. This is facilitated by use of the camera, which allows the field of observation to be changed, thus favoring players’ interdependence (Fabricatore et al., 2002). The shared visual space is useful in reaching collaborative solutions to visually complex tasks; complementing verbal communication between participants to describe the virtual environment (Gergle, Kraut, & Fussell, 2004).
Regarding the specific difficulties of CMPGs and space, we propose the following guideline:

- The system must relate camera control to the interaction of the characters on the screen, so as to favor players’ interdependence and the exploration of the virtual world when appropriate.

Examples of commercial video games that correctly satisfy these guidelines are “Super Smash Brothers Brawl” (Nintendo, 2008) and “Sims Series” (Electronic Arts, 1997).

9. Recognizable elements

In CMPGs, playing time is adjusted to the classroom time available (Susaeta et al., 2009); in this sense, it is necessary for characters and elements on screen to have distinctive traits that stand out (color, shape and action) allowing for quick recognition and differentiation between them (Cheng & Yeh, 2009), thus boosting learning and playability (Sundar, Xu, & Bellur, 2010). Emotional proximity between the player and his/her character improves when the player has the possibility to choose his/her character’s distinctive traits. This improves teamwork as well as discerning actions in the game according to role (Dickey, 2007), which supports the fantasy of the game (Amory, 2007; Hinske et al., 2008). A clear distinction of the elements on the screen allows a delimitation of the quests, linking the narrative structure with the elements that compose, characterize and differentiate the many scenes of the virtual world (Lim, 2008). Additionally, adequate design of onscreen elements and character animation stimulates positive emotions in players (El-Nasr, M., Aghabeigi, B., Milam, D., Erfani, M., Lameman, B., Maygoli, H., & Mah, S., 2010).

The use of a large screen improves element recognition and the participants’ immersion in the virtual world (Bao & Gergle, 2009). The appropriate use of the entire screen improves video-spatial abilities of diverging or multiple attention (Greenfield, 2009). This is aided by the three-dimensional design of the images and their relevance to the players’ culture, which improves subjective immersion in the game (Dede, 2009).

Regarding character design, we present the following guideline:

- Characters and elements on the screen must have distinctive traits that capture the players’ attention (color, shape, and action).

Examples of commercial video games that correctly satisfy this guideline are “Super Smash Brothers Brawl” (Nintendo, 2008) and “Sims Series” (Electronic Arts, 1997).

10. Accessible language
The clarity of the language of the texts on screen, adjusted to the needs of the players, is related to a logical thinking structure which encourages the construction of problem solving hypotheses in players (Gee, 2005). Experiences developed to stimulate abilities for interactively building stories using computational tools in children (Carbonaro et al., 2008) indicate that it is possible to design a game with a grammatical structure that includes all participants. Also, narration that is simultaneous with the images on the screen is a form of multimedia activity that favors integration of information and learning (Moreno & Mayer 2000), while at the same time controlling the cognitive load by maintaining coherence between the visual and verbal information presented to the user (Plass, Moreno, & Brünken, 2010).

The structure of the text and the number of words affect reading time (Yan & Tourangeau, 2008). The average number of words a person can retain in an experimental situation is seventeen (Capner, Scarcia, & Graham, 2007), and the comprehensive reading of an item is linked to an average length of fifteen words (Velez & Ashworth, 2007). Additionally, the text must support both the storyline and the players’ motivation (Dickey, 2006), offering information that allows understanding of the meaning of the elements on screen, linked to the development of quests (Amory, 2007). In coherence with the images on screen, texts must orient students to carry out actions that allow effective coordination within the game (Susaeta et al., 2009).

Based on the previous analysis of textual and spoken language, we propose the following two guidelines:

- The text on the screen must have a clear message, be concise and easy to read, facilitating the comprehension of the elements presented in the scene.
- Spoken text should be preferred over written text because it induces less cognitive load.

Examples of commercial video games that correctly satisfy these guidelines are “Final Fantasy X” (Square Co, 2001), “Final Fantasy XIII” (Square Co., 2010) and Mass Effect 2 (Bioware, 2010).

11. Avoid information overload.

Information overload dissipates players’ attention in the game’s activities (Susaeta, et al., 2010). When information is distributed in the available space, and graduated in time, interaction among participants improves (Moraveji, Inkpen, Cutrell & Balakrishnan, 2009). Text, animation and audio occupy the user’s perceptual bandwidth; therefore the coordination of information mediums must be functional to the activity, in order to boost interactivity (Sundar, Xu, & Bellur, 2010). Emotional proximity between the participant and his/her character improves when the participant has the possibility to choose the character’s traits; this boosts teamwork and allows distinction between the different roles in the game (Dickey, 2007). In the same sense, game entities, when distinguishable from
different types of information in a visible place, allow players to see, remember and participate (Fabricatore et al., 2002).

Appropriate management of information in games (text, images, and sounds) within a learning context promotes relational thinking and helps avoid concentrating on isolated events or abilities (Gee, 2005). The shared visual space favors the resolution of tasks that are visually complex in their spatial relations when information feedback is organized, evident, and immediate (Gergle et al., 2004). The different sources of information, as a whole, allow the construction of the game’s narrative structure, which in turn allows participants to define an action circuit (Amory, 2007). Systematic management of information also favors learning from a constructivist perspective, as it allows participants to design strategies in solving the problems proposed by the game (Ang, Avni, & Zaphiris, 2008).

Information overload can be managed by applying the following guideline:

- Individual information must not stand in the way of collective information and must be relevant to the problem that needs to be solved.

Examples of commercial video games that correctly satisfy this guideline are “Age of Empires Series” (Microsoft, 1997) and “Starcraft Series” (Blizzard Entertainment, 1998).

### 3.6 Holism

This last category provides a final guideline that gives a holistic vision of the game as a whole, combining all the elements in the previous section to create a unified experience. The question asked with this final guideline is: how can a holistic experience that satisfies the ludic and instructional aspects of the game be created?

#### 12. Action guide

This final guideline links all aspects of the game. The design is contained in a document that details the possible steps within the game and defines communication, both amongst players and between them and the game (Zagal et al., 2000). An action guide allows developers to specify all the necessary attributes for complete and consistent action within the game, incorporating instructional and technological aspects that add to the organization and evaluation of the sequence of activities (Martínez-Ortiz et al., 2008; Moreno-Ger et al., 2008).

An action guide should link and regulate different ludic, methodological and collaborative processes which operate simultaneously in the game (Hamalainen, 2008), so as to assure that the elements on screen are linked in a narrative that promotes immersion (Amory, 2007) and the learning of all students, above the competition between themselves (Gee, 2005). Scripts must have the flexibility to adjust the game to the reality
of the classroom, both in the way that the game’s quests are proposed (Lim, 2008) and in the design of content presentation (Chang et al., 2009).

The final guideline can be summarized as follows:

- The game must have a systematic design that includes the educational and ludic aspects, through a script that specifies action sequences, possibilities for action, and events that might take place both in the virtual world and in the real world.

Games such as “Dungeons and Dragons” (Wizards of The Coast, 1997) use different guides to establish the basis of the game, the roles of the players and mediator, the narrative, and the interaction between them.

Table 2 summarizes the guidelines, showing the associated problem that each one solves, and how they are classified according to the twelve categories:
**Game mechanics: how should the game be played?**

1. **Interactivity and guidance**
   - The game must offer guidance, both for individual and collective action, through precise, timely and constant information regarding success and failure in performance.
   - The user’s interaction with the game must be simple and intuitive, and not add unnecessary complexity to the game.

2. **Mechanics linked to learning objectives**
   - The curricular content must be embedded in the game’s functioning mechanics in such a way that the game’s success is conditional to understanding its content.

**Game progression: how should the game evolve?**

3. **Clear narrative**
   - The game must have a base story that allows the participants’ immersion.
   - The narrative should be composed of quests and challenges that define collaborative activities in a sequential and precise pattern.

4. **Gradual increase in difficulty**
   - The videogame must have a script with a complexity structure associated to instructional strategies.
   - The learning progression needs to be reflected by the instructional strategy and the difficulty progression in the game.

**Methodology: how does the game help the instructional strategy?**

5. **The teacher is a mediator during the game**
   - The game’s design must have a flexible structure that enables the teacher, who is the game moderator and guides the flow of actions, to adjust the game to the actual participation of the students in the classroom.

**Collaboration: how can teamwork between the game’s participants be improved?**

6. **Organize face to face interaction**
   - The game must use elements such as the underlying story and scene cuts to favor the teacher’s mediation and promote communication between students.

7. **Mechanics linked to collaboration**
   - Collaboration must be embedded in the game’s functioning mechanics so that its success is conditional to having worked collaboratively.

**On-screen information: how should the game look?**

8. **Adequate spatial distribution**
   - The system must distribute characters and activities around the map so as to take advantage of the available space.
   - The system must relate camera control to the interaction of the characters on the screen, so as to favor players’ interdependence, and the exploration of the virtual world when appropriate.
   - Spatial distribution should correctly relate aspects of the embedded knowledge to its connection with the real world.
9. Recognizable elements
   - Characters and elements on the screen must have distinctive traits that capture the players’ attention (color, shape, and action).

10. Accessible language
   - The text on the screen must have a clear message, be concise and easy to read, facilitating the comprehension of the elements presented in the scene.
   - Spoken text should be preferred over written text because it induces less cognitive load.

11. Avoid information overload
   - Individual information must not stand in the way of collective information and must be relevant to the problem that needs to be solved.

12. Action guide
   - The game must have a systematic design that includes the educational and ludic aspects, through a script that specifies action sequences, possibilities for action, and events that might take place both in the virtual world and in the real world.

Holism: how can a holistic experience that satisfies the ludic and instructional aspects of the game be created?

Table 2: A list of design guidelines for classroom collaborative games

4. Experimental study with redesigned version of the CMPG

4.1 CMPG Redesign

Using the guidelines previously described (table 2) a series of improvement activities were performed to the original ecology CMPG games. In order to prioritize the improvements in the game, the importance of each guideline for this particular game was analyzed, allowing us to categorize them into two groups: primary guidelines and secondary guidelines. This distinction was based on both the general importance of the guideline in defining the learning and game experience, and the specific improvements that were needed considering the problems originally detected.
4.1.1 Primary guidelines

Action guide:

A major improvement to the design of the CMPG was the development of a script, where the presentation times for texts and events that the students see on screen are coordinated with feedback mechanisms for each quest, which are defined both for individual and collective actions. The goal of this script is to improve the game’s coherence, expressed in the students’ motivation to participate in the activity.

The teacher is a mediator during the game:

Another important problem in the original implementation was the inability of the teacher to control the flow of the game. After the game started, the teacher lost the focus of the students in the game and it was really hard to get it back. To solve this problem, the possibility of stopping the game was introduced so the teacher could control the flow and support the students’ work.

We explicitly designed two types of pauses: during the game (development pause, which can be one or many pauses), and at the end of the game (final pause). To improve student comprehension and participation in the activity, we specified guiding questions for development pauses with the goal of reinforcing specific game elements or concepts. Some of the guiding questions to stimulate the discussion between the teacher and students were: Why is there an alert message on the screen? What can each student do to solve this situation as a group? What are we asking from our classmates?

In the final pause, we aimed to favor the metacognition of the work carried out, expressing what was learned from the experience. The facilitating questions were: Why did we win/lose the game? What characterizes the elements? What explains the elements’ behavior? What individual or collective actions explain the final result?

Mechanics linked to learning objectives:

To improve learning, explicit game rules were designed which tell players what can and cannot be done to win the game. These rules are directly related to the learning objectives, forcing the students to advance in the game only when they understand the specific objective.

The rules were presented explicitly at the beginning, and throughout the game, showing on the screen individual and collective actions necessary in order to proceed. There were rules to hunt, plant, harvest, etc., as well as general instructions, such as “do not kill all herbivores”. These explicit rules helped to reinforce both the goals in the game and the learning objectives of the class.
Gradual increase in difficulty:

In the original game the complexity of the game didn’t allow the students to complete all the quests, which directly impacted on the learning objectives. To solve this issue, a simpler food chain was developed that adjusts the conceptual complexity of the quests as follows: Quest 1: getting to know the virtual world through collective actions and interaction with the plants; Quest 2: interaction with herbivores; Quest 3: interaction with carnivores; Quest 4: interaction with carnivores through a collaborative strategy; Quest 5 and Quest 6: maintaining the balance of the entire food chain.

Through each quest, the difficulty of both the players actions and the educational content is gradually increased; in Quest 1 players must try their individual abilities; in Quest 2 each player keeps carrying out individual actions, but with a global goal of maintaining the balance between plants and herbivores; in Quests 3 and 4 players must coordinate their individual abilities to hunt carnivores; finally, in Quests 5 and 6 players must coordinate all the characters’ abilities to maintain the balance between all the elements of the chain.

4.1.2 Secondary guidelines

Interactivity and guidance:

Alert messages were added to signal when the success of the quest was being jeopardized. Congratulatory messages were given when a quest was completed, or when a collaborative task was achieved. When a new scenario was shown it was also signaled. Whenever relevant to the game, messages about abilities and how to use them appeared constantly in every quest.

The addition of an experience bar to show points for favorable individual actions was considered, however, this was not carried out, as the curricular time allotted to the game is brief. In this way we avoided excessive information, as well as feedback mechanisms that require a learning period exceeding the available time.

Clear narrative:

A base story was presented from the beginning of the game, explaining how the characters were part of it. Videos depicting the story were used, with the goal of achieving immersion in the game. Quests and challenges were relevant to the task of balancing the food chain and were coherent with the base story.
**Organize face to face interaction:**

Participants were distributed throughout the classroom in such a way that they were all visible to each other and everyone could see the screen. This favored collaboration within the game.

In addition to the development and final pauses, which are also an opportunity for collaborative dialogues, other pauses were implemented before students began a quest (initial pause), which gave them 3 minutes to discuss and design collaborative strategies.

**Mechanics linked to collaboration:**

Interdependence between players was boosted with *implicit rules*. These rules are discovered by comparing actions between participants. They were not necessary in order to win the game, but they improved the players’ efficiency and maintained motivation to participate in a virtual world where there were things to discover. An example of an implicit guideline was the fact that the hunter could carry seeds faster than the Shaman, which could be used to optimize the game-play if players discovered this rule and coordinated their work.

**Adequate spatial distribution:**

To improve the spatial distribution, from the beginning of each quest, characters and events were distributed throughout the entire screen. Additionally, a new camera control was implemented, performing zooms in/out as characters got closer/farther away on the screen, promoting virtual world exploration.

**Recognizable elements:**

The difference between the characters (Shaman and Hunter) was accentuated, and participants could choose their character’s hair color, promoting recognition and identification. Additionally, each character action was animated. Regarding the rest of the game elements, specific shapes and colors were used to improve recognition of the plants, animals and seeds.

**Accessible language:**

The texts used in the game were redefined, changing for with brief texts, with a maximum of 15 words each and containing only information relevant to the current activity. The exposure time of the text on screen was calibrated to be appropriate to the students’ reading speed. When the instructions were presented, the game was paused and the teacher read the text on the screen to favor integration of visual and verbal information.
Avoid information overload:

Individual information (Life, Energy and Hunger) was reduced and reorganized, placed at the top and bottom of the screen, next to the character’s face. Only the character’s name was placed close to him or her. Iconic figures were used to inform about individual actions, for example, feeding.

4.2. Experimental study

A field study was performed in order to observe whether or not the modifications made according to the design guidelines helped to solve the initial problems. Participants in this research were twenty 11 to 13 year-old students from an elementary school in Santiago, Chile, where the food chain is studied as part of the sixth grade curriculum. The school had similar socio-economic characteristics to the school where the exploratory study was performed. The study was performed in two sessions, each one with 10 students because of the limitations of simultaneous players in the game (Figure 1). One of the researchers acted as teacher during both sessions.

To measure whether or not the design guidelines helped to solve the initial problems, we developed a scale of dichotomic observations in order to mark “presence/no presence” of behaviors in participants that relate to the initial problems observed (Appendix A). For each problem, one or more observations were considered as indicators of it being solved. The observations were made in every quest of the game session, marking for each student whether or not the specific behavior described by the observation was present. The percentage of students that showed the behavior of all the observations related to each problem was used as a metric to show how well each guideline helped addressing its related problem.

To analyze the observations, the sessions were filmed with three cameras that recorded the participants’ behavior in the classroom and on screen. Observation points were validated by agreement between three observers. For this study, we only took into consideration observations where the concordance index was greater than 0.75 calculated through the accordance ratio of the observers; all other observations were eliminated from the study. The final scale had 24 (out of a total of 32) observations, with a global concordance of 0.92.

In addition to these observations, we performed pre- and post-tests in order to validate that the students learned using the game. To assess the students’ learning, we designed an instrument called Evaluation Test on Notions of Food Chain Balance (NFCB), composed of 20 items with multiple-choice answers; designed according to the curricular
program (MINEDUC, 2004). This test was examined and approved by three teachers who are experts in this area of the school curriculum. The analysis of the instrument’s reliability and difficulty was done through the application of a test to 20 students of a similar age and educational level as those that comprised the study group. Cronbach’s Alpha reliability was 0.74. The difficulty of the test was analyzed with a scale that produced scores that ranged from 0.05 (very difficult) to 0.99 (very easy). The result was 0.46, calculated as the proportion of people who correctly answered the test items, which indicates that the test is of intermediate difficulty.

4.3 Results and Discussions

Using the results of the dichotomic observations (Appendix A) for every student, we calculated the percentage of students who didn’t experience each problem (Table2). The results show that more than 80% of the participants didn’t have problems with on-screen information (problems 8 to 11), and they didn’t experience a lack of coordination between all the aspects of the game (problem 12). However, other problems didn’t show this level of improvement. For example, only 32% of the students showed signs of a clear relation between game actions and learning contents (problem 2).

<table>
<thead>
<tr>
<th>№</th>
<th>Problems</th>
<th>% Students who didn’t experience the problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of feedback and guidance</td>
<td>0,50</td>
</tr>
<tr>
<td>2</td>
<td>Unclear relation between game actions and learning content</td>
<td>0,32</td>
</tr>
<tr>
<td>3</td>
<td>Unclear and weak narrative</td>
<td>0,72</td>
</tr>
<tr>
<td>4</td>
<td>Too many concepts presented simultaneously</td>
<td>0,43</td>
</tr>
<tr>
<td>5</td>
<td>The teacher role in the game was not clearly defined</td>
<td>0,58</td>
</tr>
<tr>
<td>6</td>
<td>Lack of face to face interaction</td>
<td>0,43</td>
</tr>
<tr>
<td>7</td>
<td>Lack of collaborative game mechanics</td>
<td>0,49</td>
</tr>
<tr>
<td>8</td>
<td>Poor use of screen space</td>
<td>0,83</td>
</tr>
<tr>
<td>9</td>
<td>Unrecognizable elements</td>
<td>0,87</td>
</tr>
<tr>
<td>10</td>
<td>Inaccessible language</td>
<td>0,89</td>
</tr>
<tr>
<td>11</td>
<td>Information overload</td>
<td>0,86</td>
</tr>
<tr>
<td>12</td>
<td>Lack of coordination between all the aspects of the game</td>
<td>0,92</td>
</tr>
</tbody>
</table>

Table 3. Percentage of students who didn’t experience each of the problems.

A more detailed analysis was performed, measuring for each quest of the game the percentage of the students who didn’t have each problem. The 6 quests of the game were:

1. Move as a group, plant greenery.
2. Hunt herbivore, feed character.
3. Move as a group, hunt carnivore without previous strategy.
4. Design strategy to hunt carnivore using strategy.
5. Keep balance, first attempt.

As Table 3 illustrates, when closely observing these results, we can see that for problems 1 to 7 the percentage of students with the problem changes drastically from quest to quest. For example, for Quest 2, more than 70% of the students didn’t show signs of lack of feedback and guidance (problem N°1), unclear narrative (problem N°3) and unclear role of the teacher (problem N°5), but in Quest 3, where the solution requires a group strategy, these percentages fall. We can also see that, in general, the presence of problems decreases as of Quest 4. This is especially true for problem N°2 (unclear relation between game actions and learning content) and N°7 (lack of collaborative game mechanics), where students must work collaboratively in order to achieve goals. The increase of problem N°5 (the teacher role in the game was not clearly defined) in Quest 6 is linked to an increase in the participants’ autonomy for teamwork and greater mastery of the game. Finally, problem N°4 (too many concepts presented simultaneously) and N°2 (unclear relation between game actions and learning content), were not relevant in the initial sequences of the game (Quests 1 and 2) because participants interact with the screen and the teacher individually, in order to understand the elements of the game and their characters’ attributes. But as of Quest 4, where a collaborative use of attributes is required, the number of students with these problems decreases progressively.

<table>
<thead>
<tr>
<th>Nº</th>
<th>Problems</th>
<th>Quest 1</th>
<th>Quest 2</th>
<th>Quest 3</th>
<th>Quest 4</th>
<th>Quest 5</th>
<th>Quest 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of feedback and guidance</td>
<td>0,20</td>
<td>0,78</td>
<td>0,53</td>
<td>0,40</td>
<td>0,43</td>
<td>0,65</td>
</tr>
<tr>
<td>2</td>
<td>Unclear relation between game actions and learning content</td>
<td>NA*</td>
<td>NA*</td>
<td>0,16</td>
<td>0,49</td>
<td>0,59</td>
<td>0,70</td>
</tr>
<tr>
<td>3</td>
<td>Unclear and weak narrative</td>
<td>0,71</td>
<td>0,70</td>
<td>0,59</td>
<td>0,81</td>
<td>0,82</td>
<td>0,80</td>
</tr>
<tr>
<td>4</td>
<td>Too many concepts presented simultaneously</td>
<td>NA*</td>
<td>NA*</td>
<td>0,15</td>
<td>0,70</td>
<td>0,80</td>
<td>0,93</td>
</tr>
<tr>
<td>5</td>
<td>The teacher role in the game was not clearly defined</td>
<td>0,38</td>
<td>0,75</td>
<td>0,48</td>
<td>0,75</td>
<td>0,75</td>
<td>0,38</td>
</tr>
<tr>
<td>6</td>
<td>Lack of face to face interaction</td>
<td>0,35</td>
<td>0,49</td>
<td>0,40</td>
<td>0,56</td>
<td>0,60</td>
<td>0,55</td>
</tr>
<tr>
<td>7</td>
<td>Lack of collaborative game mechanics</td>
<td>0,35</td>
<td>0,44</td>
<td>0,36</td>
<td>0,65</td>
<td>0,68</td>
<td>0,69</td>
</tr>
</tbody>
</table>

*NA = Not applicable.

Table 4. Percentage of students without problems 1 to 7 on the specific quests.

The degree to which a specific problem was solved can be interpreted as a measure of how helpful the design improvements, related to the specific guidelines, were. The four primary guidelines considered for the game redesign were linked to
problems 2, 4, 5 and 12. Of these guidelines, only the *Action guide* guideline can be seen to have successfully helped in solving the original problems. The fact that, even in the final quest, 30% of students showed unclear relation between game actions and learning content, suggest that the redesigns performed following the *Mechanics linked to content* guideline were not enough. In some quests, the clarity and impact of the role of teacher was low, and too many concepts were presented simultaneously, suggesting that the design changes related to both *The teacher is a mediator* and *Gradual increase in difficulty* guidelines were not effective for every quest.

Most secondary guidelines achieved a good result in solving the original problem. The main reason for this is that, although the redesign aspects of these guidelines were not prioritized as high as the one of the primary guidelines, most of the changes needed to improve the CMPG were small and easy to implement, and the problems themselves were simple. The problems related to the primary guidelines, however, were more complex, involving the interplay of many elements during the session.

The results of the pre/post-test experiment showed that scores obtained on the NFCB test are higher in the post-test, with statistically significant differences ($p < 0.001$) and medium effect (Cohen’s $d = 0.51$). The gender analysis showed that this result is present both in boys and girls, as can be seen in table 5.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard deviation</th>
<th>T</th>
<th>Significance (bilateral)</th>
<th>Cohen’s $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre- Test</td>
<td>9,62</td>
<td>2,71</td>
<td>3,13</td>
<td>0,005</td>
<td>0,5 Medium</td>
</tr>
<tr>
<td>Post- Test</td>
<td>11,10</td>
<td>3,34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Girls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre- Test</td>
<td>9,05</td>
<td>2,34</td>
<td>2,08</td>
<td>0,051</td>
<td>0,55 Medium</td>
</tr>
<tr>
<td>Post- Test</td>
<td>10,32</td>
<td>2,38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 5. Comparison of pre- and post-test by gender.*

5. Conclusions

The main contribution of this work is the definition of a set of guidelines that help the design of CMPGs. These guidelines were proven to be useful in general when redesigning a game to solve its original problems, which was shown both by the results of the observations made of the activity and also by the learning results measured with the pre-post experimental design. The goal of any educational game is to improve the learning of the students, and the results obtained in this work suggest that the use of the design guidelines helped to achieve this goal. While primary guidelines, defined by their importance in defining the learning and game experience, convey different elements making the corresponding problems hard to solve, most secondary guidelines solved the diagnosed problems.
There are additional valuable lessons which were obtained from this experience. Although the design guidelines can be seen as general principles necessary to be considered in this kind of game, the detailed analysis made for each quest shows that in some circumstances some guidelines could be left aside, and in other moments they may even be contradictory. For example, the initial quests, which are focused on teaching the game, could limit some collaborative mechanics in order to ease the learning process. Also, in the final quests, where the students are mastering the game, the teacher may take a more secondary role and decrease his/her interventions in order to maximize the engagement of the class with the game. This suggests that the importance of some guidelines varies throughout the game, and this must be considered in order to make more informed design decisions.

The set of guidelines presented here are clearly not complete, but they present a good step in defining principles that can guide the process of CMPGs. Some of the guidelines explained can be considered as basic interface design principles (i.e. on-screen information guidelines), but we still considered it relevant to include them here, and restate their importance for this type of game. As future work, we would like to explore in more detail how these guidelines (and possibly additional ones) can be best used in different moments in the game, which would help to decide when a specific guideline must be applied and when it may be optional.

The implementation of videogames in the classroom has a level of effectiveness and results that depend on design (Amory, 2007). We must take into account that the game’s mechanics are the first barrier in learning the contents provided by the CMPG. This is why, in a preliminary study, we considered that the use of a videogame in the classroom requires one session to master the game and another to use it in the learning process (Susaeta, Jimenez, Nussbaum, Gajardo, Andreu, & Villalta 2010). However, this study demonstrated that, if the CMPG’s design doesn’t carry the information load that is typical in online games, and maintains its ludic properties, it allows players to learn its mechanics and components in a few minutes, and thus begin the process of solving quests linked to learning in one session.

The design guidelines presented here can be complemented with additional methods and guidelines for the curricular integration of contents and quests. For example, Bloom’s revised taxonomy (Anderson et al., 2001) has been used as a design guide for defining the learning objectives and, based on those objectives, specifying the quests (Echeverría et al., 2011). The combination of these guidelines is something we plan to study further, in order to understand how they can be used together to create better educational games for the classroom.

Acknowledgements
References


86. YouTube Videos (2010); http://www.youtube.com/watch?v=nb3_AoZDq3M and http://www.youtube.com/watch?v=5NtkrV83DC0
Appendix A

Dichotomic observations used to measure how well the different problems of the original games were resolved in the redesigned version.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Associated problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 More than half of the characters are grouped in one specific sector of the screen, while game events are happening in a different sector.</td>
<td>Poor use of screen space</td>
</tr>
<tr>
<td>2 Characters are participating in all of the game events, located in different parts of the map.</td>
<td>Poor use of screen space</td>
</tr>
<tr>
<td>3 The player recognizes his/her character on the screen.</td>
<td>Unrecognizable elements</td>
</tr>
<tr>
<td>4 The player identifies his/her role as Shaman or Hunter in the game.</td>
<td>Unrecognizable elements, Information overload.</td>
</tr>
<tr>
<td>5 The player actions are coherent with the current elements on screen.</td>
<td>Unrecognizable elements, Information overload.</td>
</tr>
<tr>
<td>6 The player actions are coherent with the current actions being made by elements on the screen.</td>
<td>Unrecognizable elements, Information overload.</td>
</tr>
<tr>
<td>7 The player keeps his/her focus on the screen when there text instructions are displayed.</td>
<td>Inaccessible language, Information overload.</td>
</tr>
<tr>
<td>8 The player actions are coherent with the instructions on screen.</td>
<td>Inaccessible language, Information overload.</td>
</tr>
<tr>
<td>9 The player performs the correct actions when feedback information changes (level of hunger, energy, life).</td>
<td>Lack of feedback and guidance</td>
</tr>
<tr>
<td>10 The player talks with other players about the story and game elements.</td>
<td>Unclear and weak narrative, Lack of collaborative game mechanics</td>
</tr>
<tr>
<td>11 The interaction between the player and the rest of the characters is the most efficient in order to solve the quest (he or she takes part in two or three player activities with success)</td>
<td>Too many concepts presented simultaneously, Unclear relation between game actions and learning content, Lack of collaborative game mechanics</td>
</tr>
<tr>
<td>12 The player states his/her opinion during pauses or gameplay.</td>
<td>Unclear and weak narrative, Lack of face to face interaction, Unclear relation between game actions and learning content</td>
</tr>
<tr>
<td>13 The player suggests concrete actions to other players during pauses or gameplay.</td>
<td>Lack of face to face interaction, Lack of collaborative game mechanics</td>
</tr>
<tr>
<td>14 The player asks questions or gives support to other players during pauses or gameplay.</td>
<td>Lack of face to face interaction, Lack of collaborative game mechanics</td>
</tr>
<tr>
<td>15 The player is disruptive during pauses or gameplay.</td>
<td>Lack of face to face interaction, Lack of collaborative game mechanics</td>
</tr>
<tr>
<td>16 The actions performed by the player relate to solving the quest are caused by a comment made by another player.</td>
<td>Lack of collaborative game mechanics</td>
</tr>
<tr>
<td></td>
<td>The actions performed by the player relate to solving the quest are caused by the player’s own initiative.</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>The player doesn’t perform actions related to solving the quest.</td>
</tr>
<tr>
<td>19</td>
<td>There was agreement between the players and the teacher as to the best strategy to use in solving the quest.</td>
</tr>
<tr>
<td>20</td>
<td>The player shows satisfaction about his role in the game (positive emotional expressions).</td>
</tr>
<tr>
<td>21</td>
<td>The player doesn’t show satisfaction about his role in the game (positive emotional expressions).</td>
</tr>
<tr>
<td>22</td>
<td>The player appears indifferent to the current events in the game.</td>
</tr>
<tr>
<td>23</td>
<td>The player shows that he learned the content during the game, making comments that suggest that he knows what to do and why he won or lost.</td>
</tr>
<tr>
<td>24</td>
<td>The player appears confused.</td>
</tr>
</tbody>
</table>