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## Guidelines for designing and using collaborative-competitive serious games



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### ABSTRACT

There are already evidences of Serious Games (SG) effectiveness in teaching-learning processes for some areas of knowledge. Some studies analyzed the influence of different interaction modes, with focus on competitive and collaborative SG modes separately. New research studies however, suggest that SG with collaboration and competition altogether, could also provide benefits. A review on Collaborative-Competitive SG (CCSG) was performed, but no methodology was found to design such games. Instead, different research studies claim that specific design features should require attention in the design phase since they may compromise the success of a CCSG in terms of usage and learning. Once the outcome is said to be sensitive to those features, we hypothesized that a CCSG with such concerns altogether still promote learning. Thus, a new CCSG was designed considering all of these features, implemented, put to use and tested. Learning evaluations on a pre-experimental research design showed an increase in knowledge acquisition and level of confidence on students that played the resulting game. Data show that joining all design concerns regarding a CCSG did not compromise game capability to promote learning. Based on the feedback of game use, more features arose and we advocate that they should be considered as design concerns as well. Game design features identified in this work have been proved effective and can be used as guidelines for future educational CCSG.

### 1. Introduction

Existing research argue that video games can be helpful in the teaching-learning process by mixing interactive features, fun, immersion and game dynamics with educational content (Prensky, 2003; Selwyn, 2009; Van Eck, 2006). Games specially developed for teaching and training are called Serious Games (Sawyer & Rejeski, 2002; Susi, Johannesson, & Backlund, 2007). Several work (Han-Yu & Gwo-Jen, 2013; Padrós, Romero, & Usart, 2012; Paraskeva, Mysirlaki, & Papagianni, 2010) have shown the efficacy of Serious Games (SG) in different areas of knowledge.

In order to produce intrinsic motivation, activities should maintain an optimal level of difficulty, with clear objectives and feedback, offering sensory stimuli, sense of control, and sense of involvement with the environment and with the characters of the game (Chiu-Pin, Shwu-Ching, & Hui-Chun, 2008; Grassioulet, 2002). The fun is another prime element for a game success, but it is a subjective issue, either in personal and contextual matters (Cybis, Betiol, & Faust, 2010). Thus, as a successful learning process is linked to motivation (Paas, Tuovinen, Van Merriënboer, & Darabi, 2005; Prensky, 2003), game design decisions should be supported by systematic motivational aspects. Some main elements are (Malone & Lepper, 1987; Dweck, 1986; Keller, 1987, 2008): goals,

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uncertain outcomes, performance feedback, self-esteem promotion, perceptual arousal, variability in challenges, confidence, sensory and cognitive curiosity, relevance, control (choice opportunities and responsive learning environment), fantasy, cooperation/collaboration, competition, space for recognition and satisfaction (through natural and positive consequences and equity).

Motivation and fun are sensible design features but have received some attention already. On the other hand, there are also some research studies that started to focus on specific aspects that seem to have some influence on the learning process, among them, the influences and impacts of different interaction modes, like collaboration and competition (Liu, Li, & Santhanam, 2013). There are already research studies that have shown that collaborative educational environments, as well as competitive educational environments, can help in the improvement of different kinds of skills (Pareto, Haake, Lindström, Sjöden, & Gulz, 2012). Collaborative interactions seem to have greater influence on social and synthesis skills, whereas competitive interactions seem to have greater influence on analysis skills and motivation to spend more effort and concentration in an activity (Fong-Ling, Ya-Ling, & His-Chuan, 2009; Malone & Lepper, 1987).

The benefits of putting together both collaborative and competitive interaction modes, however, are not clear: games like this could inherit benefits of both interactions modes and maybe lead to other benefits, or they could interfere in each other compromising benefits from both. As the development and use of Collaborative-Competitive Serious Games (CCSG) is still a new study subject – in an exploratory stage – there is not much research on how to design such games (Blind Review A, 2013). It is important to identify design features that have been used in CCSG and to determine if such games can effectively promote knowledge acquisition before start making comparisons between interaction modes or other educational approaches and artifacts. Thus, the few reports on the scientific literature about this subject should be revised in order to find designing details, common features and usage guidance.

Through a systematic literature review, this paper put together some knowledge scattered in the literature that help designing CCSG. In order to check if such mix of guidelines yield a SG that still promote knowledge acquisition, a new CCSG was developed based on those principles and an exploratory research with a pretest posttest pre-experimental design (Fraenkel, Wallen, & Hyun, 1932) was performed. An assessment was done in order to see if the game could improve player's knowledge and level of confidence in a subject matter, i.e. if the game can be helpful in the learning process. The assessment proved that the game is effective but, more importantly, new features concerned with the design of CCSG were gathered during usage. These, altogether with the former set, compose a group of design features that can help design any future CCSG.

In order to present the study and its results, this paper is structured as follows: the second section presents related works and the literature review on CCSG. The third section presents an analysis of some generic CCSG characteristics glimpsed. The fourth section presents the new CCSG produced and its features. The fifth section presents the conducted intervention and its main results. The sixth section discusses the lessons learned during the study and the seventh section presents the conclusion.

## 2. Related work

Malone and Lepper (1987) presented a motivational taxonomy for designing educational environments focusing on games, in which both cooperation and competition are classified in two different modes, exogenous and endogenous, as follows:

- Exogenous cooperation: there is no link between participant tasks. Each team member can complete his/her task individually (e.g. relay race);
- Endogenous cooperation or collaboration: the tasks of each participant are linked and there is a dependency between team member's (e.g. soccer team);
- Exogenous competition: there is no direct relationship between participants' actions, such that one competitor cannot interfere in the other's performance (e.g. 100-metre race);
- Endogenous competition: there is a relationship between participants' actions, such that one competitor may interfere in the other's actions and performance (e.g. chess game).

Among these modes, endogenous cooperation and endogenous competition enable greater intrinsic motivation of participants (Malone & Lepper, 1987). The intrinsic motivation leads to a spontaneous participation in activities without any external interference. Activities can also be enhanced by extrinsic motivation, when participants act because of external influences like rewards – e.g. good grades or money – or punishments – e.g. low grades or penalties. Exogenous approaches are more prevalent either for Commercial off-the-shelf (COTS) games as for SG, while endogenous approaches are rare to find.

Collaboration (cooperation) and competition are interactions that might conflict between each other. Their definition are subject to some debate as we see following. Although there has been some discussion about the meaning and differences between cooperation and collaboration, we focus on the interdependency in the participant's activities, which is mainly attributed to collaboration (Camarihna-Matos & Afsarmanesh, 2008). Nevertheless, these terms will be considered as synonyms hereafter.

Regardless the definitions of collaboration and competition, scientific work have been published concerned with how to achieve learning objectives using these interaction modes. In order to find scientific work involving CCSG, a systematic literature review was performed following the protocol presented in (Petersen, Feldt, Mujtaba, & Mattsson, 2008). The search query was:

*("serious game\*") AND (collaborat\*) AND (compete OR competi\*)*

The search (held in 2013) in ACM Digital Library (ACM), IEEE Xplore (IEEE), Science Direct (SD), Scopus e Web of Knowledge/ Science (WoK) resulted in 742 papers, from which 50 papers complied with selection criteria at first, but just 17 papers were selected after all filtering process, which presented 12 different studies involving CCSG (i.e. some CCSG were discussed in more than one

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