Designing for Children
- With focus on 'Play + Learn'

Design Issues in Serious Games for Children's Learning

G. M. Mejía, Universidad de Caldas, Colombia, mauriciomejia@disenovisual.com
F. C. Londoño, Universidad de Caldas, Colombia, felipecl@ucaldas.edu.co

Abstract: The use of digital technology for games with aims beyond entertainment is extensive. The game community calls it the genre of serious games, which can have educational, commercial, or social change purposes. Games for learning have particular potential for children because they are avid players of digital games and usual targets in the learning policies of governments. This essay studies issues that designers have to account for serious game design for children. This analysis is based on a project of designing a serious game for in children in Colombia called *Civia*, in which the authors participated as principal investigators. The authors used the simplified three-stage design process that is common for most design methodologies: analysis-divergence, synthesis-convergence and evaluation. Cognitive development of children was the issue derived from the stage of analysis-divergence, conceptual design considerations were derived from the synthesis-convergence stage, and learning assessment of children became the most relevant issue in the evaluation stage.

Key words: Serious games, design, children, children's cognition, conceptual design, learning assessment, social competence.

1. Introduction

The use of digital technology for games with aims beyond entertainment is extensive. The game community calls it the genre of serious games, which can have educational, commercial, or social change purposes[1]. Some of these games are short interactions that have a concrete message. For example, *Darfur is Dying* from the MTV channel can be played in less than 15 minutes, and the player can easily understand the difficulties for people in Darfur as a result of a violent conflict. Other games are more complex simulations and look for explanations of strategies or situations. For example, *A Force More Powerful* from the International Center on Nonviolent Conflict, explains how to organize activist groups to fight peacefully against political dictators and corruption.

There is a general agreement that games are a useful educational tool. Certainly, toys and games have traditionally been used in education, especially for preschool children (Hartman & Brougère, 2004). Despite this, educational researchers have reported that children are playing less inside and outside school for reasons such as less playful time spent with parents and more importance given to cognitive skills in school (Golinkoff, Hirsh-Pasek, & Singer, 2006). Golinkoff et al. have defended game learning benefits and have called for an increase of game time for children. Authors like Prensky (2001) and Gee (2003) have studied the potential that video games have for learning. They argue that video game players are active and motivated in the interaction, which creates meaningful learning transferable to the real world. Moreover, recent studies have reported that children actually use video games for learning (Sánchez Buron, Rodriguez, & Fernández Martín, 2009; Manders, 2008).

These findings show the need for studies about serious games design. This essay studies issues that designers have to account for in serious game design for children. This analysis is based on a project of designing a serious game for children in Colombia called *Civia*, in which the authors participated as principal investigators. The simplified three-stage design process described by Jones (1970) was utilized, which is common for most design methodologies: analysis-divergence, synthesis-convergence and evaluation. Based on each stage of the *Civia* design process, the authors indentified the most relevant and challenging issues for designers and researchers that can be generalizable to other projects. The cognitive development of children was the issue derived from the stage of analysis-divergence, conceptual design considerations were derived from the synthesis-convergence stage, and learning assessment of children became the most relevant issue in the evaluation stage.

2. *Civia* Game

Civia is a multiuser online game targeted at children to learn about social and citizenship competencies (Mejía, Londoño, & Escandón, under review). The game intends to support one of the Colombian central policies in education; the game concept and content use, as a basis, the guidelines from the Ministry of Education in citizenship competencies (Ministerio de Educación Nacional, 2004). *Civia* was developed as an applied research project using a systematic and documented process. First, in the analysis-divergence stage, the team studied children's contexts in Colombia and possible game structures. In the synthesis-convergence stage, a game concept and the core mechanics of the games

were created to connect children's needs and learning objectives. Finally, the researchers evaluated the effectiveness of learning while children played the game.

The game proposes a fantastic scenario, in which the players have a collective challenge to survive in a futuristic world that has suffered an environmental crisis. Resources are limited, and players need to figure out the best way to sustain their *Civia* world. The core mechanics of the game are designed in such a way that prosocial behaviors win benefits for the players. Thus, while children are focused on the game challenge, they are unaware that they are learning prosocial behaviors and citizenship competencies. The game also includes complementary individual challenges and social tools. Figure 1 and 2 show screenshots of avatar selection and scenario interface.

Figure 1. Avatar selection.

Figure 2. Scenario interface.

3. Children's Cognition

The first issues discussed below come from the stage of analysis-divergence and are related to the cognitive development of children. A game, even serious, must first provide fun. This characteristic explains the success of serious games to facilitate knowledge assimilation and skills building. A serious game needs to be seen as a leisure activity rather than a cognitive task. For children this is more relevant, because the cognitive differences among developmental stages show evidence that playful activities compel children's attention (Bjorklund, 2005). This analysis was derived from the specific cognitive characteristics of children in the transition from preadolescence to adolescence studied in the *Civia* project, but other children's developmental stages might have other specific considerations. The cognitive issues in game design for children discussed in this section are limitations of children's operational stages, advantages of both automatic and effortful information processing, and benefits of play to sustain attention and increase resistance to interference.

The first concept is limitations of children's operational stages. The concept of operations belongs to the Piaget's theory of developmental psychology that describes four stages in child development: sensorimotor, preoperations, concrete operations, and formal operations. Operations refer to the transformation of mental schemes that children develop in the stages using symbolic reasoning (Bjorklundk, 2005). Since the stages are an incremental process, design decisions must be based on the limitations of children's mental capacity at each stage. For example, a game for children in the preoperations stage should not contain abstract reasoning belonging to the formal operations stage. In *Civia*, taking into account the limitations of the children's operational stages, the team targeted the formal operations stage to facilitate learning of citizenship competencies, which require abstract thinking. Although children in previous stages may understand the game's core mechanics, they may not be able to grasp the competencies targeted, since their mental schemes are incompatible with their level of thought abilities.

The second cognitive issue comes from information processing theories of cognitive development. These theories try to explain how humans access and retrieve information based on the concept of limited capacities of memory and processing. One of the assumptions is that there are two extremes that demand information processing capacities: automatic processing and effortful processing. Automatic processing does not require mental effort, is not available to consciousness, does not interfere with other processes, and does not vary with individual differences of intelligence, motivation, and education (Bjorklund, 2005). Depending upon the design problem, one or the other extreme maybe adequate. In games it is preferred that learning objectives be automatically processed to avoid the impression of learning task, and to let children focus their effortful processing on the game core mechanics. For this, the *Civia*'s team decided to put the content about citizenship competencies at an automatic level. That is to say, that the game presents a challenge that does not directly explain competencies like respect or how to interact peacefully. Instead, the players focus on game challenges and, hence, while children are figuring out game strategies for survival, it is expected that they will be assimilating desirable prosocial behaviors.

The last cognitive issue is related to sustaining attention. Younger children have less ability to inhibit irrelevant information and sustain attention in a central process. Only around the age of sixteen will children reach a level of resistance similar to that of adults. (Bjorklund, 2005). Thus, for the design of serious games, assuring game play immersion is critical, because it supports longer and stronger sustained attention in a player who might

be more susceptible to interference. This lends support to the idea that digital games have the potential to generate long immersion trances and learning. However, it is a mistake to think that the technology alone guarantees effective learning. Murray (1997) explains that immersion can be achieved with a book, a TV show, or a digital game; but it also needs a content component. Thus, adequate narration and game play blended with technology are necessary for games to be powerful tools for children's learning. In *Civia* the design decisions also dealt with the limited resistance of children to cognitive interference, because they are using conscious processes in the game play and narrative, which has a powerful potential for immersion.

4. Conceptual Design

From the synthesis stage, the authors found that conceptual design becomes essential to connect game play design challenge with learning objectives. The challenge of designing for children is to synthesize these two complex factors, which seem opposite, into one concept. Game concept is the foundation on which to build everything else. Although visual aesthetics and usability remain relevant, the concept is central to the design problem. It defines essential game play, narrative argument, and game core mechanics. The designer's challenge becomes more complex in serious games for children, since the majority of commercial games have been based on violent topics, which are undesirable in education.

Raw learning content is usually not exciting for learners. The simple translation of content to game content is likely to be uninteresting for players, and a game that is not interesting is not a game. Conceptual design must be a process that uses creative ways to design engaging games. Two issues relevant to serious game design for children are explained below: rhetorical tropes and reuse of interactive models. Rhetorical tropes, like metaphors and analogies, can deliver the content in an indirect and effective way. Bonsiepe (2000) already advocated for a designer who is a specialist in visual rhetoric to facilitate the assimilation of complex information. In the *Civia* project, for example, the notion of collective survival after an ecological crisis in the future was used as a metaphor of current Colombian social problems that remain unresolved due to citizens' inability to interact peacefully and collectively. Thus, the rhetorical model conveys the message in an indirect way, creating an efficient communication.

The additional issue is the reuse of interactive models, which is a powerful tool for designers of serious games. Looking at the advantages and disadvantages of game genres

and technologies, designers can decide what are suitable options for children. For example, toddlers may enjoy repeatable single challenge games or simple puzzles, while preadolescents may need more complex games. The learning objectives determine this decision. For example, historical content may use adventure and strategy game types, while social competence content may require role-playing games. Conceptual decisions in game design must study carefully what different genres and technologies offer to improve the game effectiveness.

In *Civia,* the team reused the interaction model of multiuser games. Although multiuser games traditionally are not directed toward children, because they are based on complex social structures, game producers have recently been designing games adapted for children without sacrificing fun (Aihoshi, 2008). These types of games correspond to a design solution because they offer social media tools and interaction among players, which offer potential benefits for social and citizenship competencies. This decision was also supported by the fact that preadolescents and adolescents are more likely to play complex games with long interactions and enjoy social media tools. In addition, this interaction model of multiuser games offers another advantage according to Piagiet's theory of developmental psychology called intrinsic activity, which states that children learn more from peers than parents or teachers (Bjorklund, 2005). This suggests that the collective challenge and social interaction of *Civia* can enhance opportunities for learning.

5. Learning assessment

In the evaluation stage, children's learning assessment is the most relevant issue. Learning outcomes determine the efficiency of serious games designed for children. Fun is the key element of games, and it is the key for serious games, too. Still, learning outcomes become the criterion for evaluating the quality of serious games designed for learning. The authors propose longitudinal measurements of competencies, for two reasons. First, one-time measurements of competencies are imprecise and may lead to questions about research validity. Indeed, evaluation of learning outcomes needs an ongoing assessment, because individuals learn in several continuous moments (D. Villada, personal communication, November 27, 2006). Second, one-time measurements do not reveal the real learning in an individual because measurements do not measure precisely unconscious processes. Serious games for children usually do not include metacognitive learning because it is better that children not be aware of their own learning when it is related more to a task rather than fun.

Therefore, longitudinal measurements are the most accurate way of assessing learning, although it is impractical for designers. A solution for this problem is the partnership with other specialists like educators or social workers, who naturally interact with children everyday. These conclusions follow upon the *Civia* experience, where the project team executed a one-time learning assessment with quantitative and qualitative data. After game interactions, the researchers found that the game increased levels of social competencies. But some questions arose about the real transference of behaviors to real life, which need longitudinal studies to be answered (Mejía et al., under review). Stevens, Satwicz, and McCarthy (2008) pointed out that it is necessary to "reconnect" the game immersion of children with their real life. Their research suggests that there are potentialities for learning with games for example, in individual knowledge building. Nonetheless, they added, research is needed to find out if the "reconnection" is generalizable.

6. Conclusions

Serious games are becoming an important area for using technology for learning goals. Rapidly, the genre has grown with a large list of titles available for different needs and audiences. This children's audience creates a demand for research to create appropriate design principles for serious games for children. This paper has reported specific evidence and experience usable in other design projects about serious games for children. Perhaps, the most relevant issues are related to children's cognition, in which developmental theories can be applied and interpreted in order to create effective serious games. Immersion and fun are clearly the main design goals in order to create a learning situation that fits children's cognitive needs.

To achieve this, designers must understand the specific cognitive stages in their children's audience to design an appropriate concept. Effective conceptual design combines fun and learning, which is possible with tools like visual rhetoric and reuse of interactive models. Whereas visual rhetoric relies on designers' creative skills, reuse of interactive model consist of benchmarking evaluations that can lead to recycling of already successful interfaces of games. Also, the authors call for ensuring the inclusion of ongoing evaluation stages in which designers and researchers can identify real learning outcomes and how design principles and tools have affected the learning process.

Education and psychology researchers generally agree that video games are a useful tool for the learning engagement, but they diverge in how the learning is produced (Kerr,

2006). Michael and Chen (2006) recommended types of research needed to clarify the success of serious games. They drew attention to improving the effectiveness of educational processes, exploring artificial intelligence tools and behaviors of non-player characters of digital games, promoting free software and low-cost tools for children's games, improving game evaluation tools, and promoting the acceptance of serious games for learning in society. Even though design research can contribute to all these issues, it must specifically address the processes of creating game innovations and discovering interface principles that enhance learning. Research projects on game design and development like *Civia,* are helping to indentify generalizable design principles. Surely, more initiatives will follow to add more insights to this field of research.

Acknowledgements

Notes

[1]For comprehensive lists of serious games visit http://www.seriousgames.org or http://www.socialimpactgames.com/

References

Aihoshi, R. (2008). MMOG's are for kids. *The Escapist (153).* Retrieved from: http://www.escapistmagazine.com/articles/view/issues/issue_153

Bjorklund, David (2005). *Children's Thinking: Cognitive Development and Individual Differences.* Belmont, CA: Wadsworth Thomson.

Bonsiepe, G. (2000). Design as tool for cognitive metabolism: From knowledge production to knowledge presentation. *Proceedings of the International Symposium on the Dimensions of Industrial Design Research.* Milan, Italia. Politecnico di Milano. Retrieved from http://www.guibonsiepe.com/

Gee, J. P. (2003). *What Video Games Have to Teach us About Learning and Literacy.* New York: Palgrave Macmillan.

Golinkoff, R. M., Hirsh-Pasek, K, & Singer, D. G. (2006). Why play = learning: A challenge for parents and educators. In Singer, D. G., Golinkoff, R. M., & Hirsh-Pasek, K (Eds.), *Play = Learning: How Play Motivates and Enhances Children's Cognitive and Social-emotional Growth.* (pp 3-12). Oxford: NY: Oxford University Press.

Hartman, W. & Brougère, G. (2004). Toy culture in preschool education and children's toy preferences. In Goldstein, J., Buckingham, D, & Brougère, G. (Eds.), *Toys, Games, and Media* (pp. 37-53). Mahwah, NJ: Lawrence Erlbaum.

Jones, J. C. (1970). *Design Methods. Seeds of Human Futures.* London, UK: John Wiley & Sons.

Kerr, A. (2006). *The Business and Culture of Digital Games: Gamework/Gameplay*. Thousand Oaks, CA: Sage Publications.

Manders, T. (2008). *Proyecto de Informe sobre la Protección de los Consumidores, en Particular de los Menores, por lo que se refiere al Uso de Juegos de Vídeo* [Project of Report about Consumers' Protection, Particularly Minors, About Video Game Use]. Bruselas: Parlamento Europeo, Comisión de Mercado Interior y Protección del Consumidor.

Mejía, G. M., Londoño, F. C., & Escandón, P. A. (Under review). Social and citizenship competencies in a multiuser virtual game. In Mura, G. (Ed.) *Metaplasticity in Virtual Worlds: Aesthetics and Semantics Concepts*. IGI Global.

Michael, D. & Chen, S. (2006). *Serious Games. Games that Educate, Train, and Inform*. Boston, MA: Thomson Course Technology PTR.

Ministerio de Educación Nacional (2004). *Estándares Básicos de Competencias Ciudadanas. Formar para la Ciudadanía… ¡sí es possible! Lo que necesitamos saber y saber hacer* [Basic Standards of Citizenship Competencies… it is possible! What we Need to Know and Know How to Do]. Bogotá, Colombia: Ministerio de Educación Nacional.

Murray, J. H. (1997). *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. New York: Free Press.

Prensky, M. (2001). *Digital Game-based Learning*. New York, NY: McGraw-Hill.

Sanchez Buron, A., Rodríguez, L., & Fernández Marín, M. P. (2009). *Los Adolescentes en la Red. Estudio sobre sus Hábitos de Comportamiento en Internet* [Adolescents in the Net. Study about their Behavior Habits in Internet]. Retrieved from http://www.ucjc.edu

Stevens, R., Satwicz, T., & McCarthy, L. (2008). In-game, in-room, in-world: Reconnecting video game play to the rest of kids' lives. In Salen, K. (Ed.) *The Ecology of Games. Connecting Youth, Games, and Learning.* Boston: The MIT Press.