

Video Games in Education of Deaf Children

A Set of Pratical Design Guidelines

Rafael dos Passos Canteri¹, Laura Sánchez García¹, Tanya Amara Felipe de Souza²
and Carlos Eduardo Andrade Iatskiu¹

¹UFPR - Federal University of Paraná, Paraná, Brazil

²INES - National Institute of Deaf Education, Rio de Janeiro, Brazil

Keywords: Deaf Education, Video Games, Educative Games, Assisive Technologies.

Abstract: Deaf communities are quite unsupported in terms of assistive technology. These communities have many special needs in terms of Education, Communication and Leisure which, most of the time, are not attended. There is a great variety of studies that ensure the benefits the educative video games bring to children. However, Deaf communities do not have satisfactory softwares of this kind as well. The present study shows a set of guidelines, based on known educative video games models and on a Deaf children education methodology, intended to support game developers when creating educational video games for Deaf children. Following the guidelines, the construction of a game for Deaf children is presented in order to show the effectiveness of the guidelines within the design process and to assess them.

1 INTRODUCTION

Deaf communities have struggled for many years for recognition due to their differentiated condition. They have been submitted to treatments with the intention of removing the “problem” that they were supposed to have. Their acquisition of certain basic rights, such as allowing the use of Sign Language, a language more natural for the Deaf, only recently began (Guimarães, 2013). After years of struggles and achievements, the Deaf began to be considered as citizens, members of a minority whose inclusion brings together social, political and citizenship dimensions (Skliar, 1999).

There is a lack of technological artifacts to support teaching and learning of the Brazilian Sign Language (Libras) for the Deaf, their families and their teachers. This shortage is observed at all levels of formal education. Even for the American Sign Language (ASL), which is the language that has the greater variety of technological support tools, this gap exists (Korte et al., 2012).

Among the technological artifacts needed for the Deaf, we can quote the electronic games. Video games form an area of extensive commercial and cultural success, but they can also be efficiently employed as educational tools. There is a vast amount of studies (Squire, 2003) (Squire and Jenkins, 2003) (Prensky, 2003) (Amory and Naicker, 1999) (Virvou

et al., 2005) (Korte et al., 2012) supporting the benefits that these games can bring to children.

Even non-educational games ensure several benefits to the children that play them, as improving the physical, mental and creative abilities of the players (Barab et al., 2005) (Bourgonjon et al., 2011) (Song and Zhang, 2008). Educational video games have the potential to, besides ensuring the advantages of entertainment electronic games, support the teaching-learning process at virtually every subject in any field of knowledge.

In this sense, this work intends to create a set of guidelines that leads the construction of video games for Deaf children education, mainly between 0 to 6 years old. This way, the creation of new games for these communities can be encouraged and oriented. The guidelines proposed are based on well-known and referential models of educative games and on a Deaf children teaching-learning methodology.

The remainder of this paper is as follows: Section II discusses related researches that have the Deaf community as the target audience, in the research group where this study was conducted. It also addresses the subjects of educative games and the teaching methodology of hypotesis. Section III presents the core of the work, the proposed guidelines. Section IV shows some features of the software developed and its assessment. Finally, Section V ends the paper with

the conclusions.

2 RELATED RESEARCH

The projects of the research group in Human-Computer Interaction for Social Inclusion of the Computer Department of *Universidade Federal do Paraná* have focused efforts in providing socially inspired and socially based technology solutions for Brazilian Deaf communities. In this sense there are the works (Bueno, 2014) (Guimarães, 2013) (Antunes, 2011).

The work of (Antunes, 2011) developed a computational model for the description of the phonological aspects of Libras signs in order to support different application needs. This is the core of the architecture that allows for the construction of technological and computational useful artifacts for Deaf communities.

(Guimarães, 2013) built a Pedagogical Computational Architecture to assist in the development of technological tools to mediate the communication and educational process between Deaf children and their hearing parents. This architecture serves as a support for Bilingual Literacy in written Brazilian Portuguese and Libras.

(Bueno, 2014) described, with focus on the users (Deaf children enrolled from kindergarten through 5th grade of elementary school), the full potential of a literacy supporting virtual environment. Such an environment will allow the teacher to select materials from several textual genres and explore them with the students aiming at learning to read and write in Portuguese.

2.1 Educational Computer Games

Video games have become one of the most important areas of entertainment nowadays. There is no way of denying the fact that children and teenagers love computer games (Virvou et al., 2005). Games are a human activity that took throughout history many anthropological, cultural, philosophical, psychological, educational definitions and meanings (Laranjeira et al., 2011).

New teaching and learning resources have been added to education to enhance learning in different ways. Digital games can make learning less mechanical, and more fun for students.

Video games have been widely used in the teaching of several subjects (Costa, 2012). Studies such as (Alves, 2005) (Schroter, 2004) (Squire and Jenkins, 2003) prove that games not only satisfy the entertainment needs of children, but also contribute to

their cognitive, social, emotional and cultural development. Besides the known benefits of video games, such as increased concentration and logical thinking (Amory and Naicker, 1999) (Melonio and Gennari, 2013), the game and the play as social actions are human activities that allow children to assimilate and recreate sociocultural experiences of the adults.

By engaging with the game, the child comes out of passivity, is faced with a challenge situation and has various tools with which he/she must solve proposed problems. When playing a game, there is a need to train new cognitive associations in order to reach a solution (Pereira, 2007). Differentiated lessons that aim to work with well-targeted and objective recreational activities are a creative way to develop the oral communication skills of learners in the classroom (Costa, 2012).

Despite the vast amount of contributions that the games bring to the school, they should not be used as substitutes for the classroom, but rather as a complementary tool used in conjunction with the class (Virvou et al., 2005). Currently writers, researchers, companies, armies, foundations and game designers are united with the goal of sharing the potential of digital games for learning (Prensky, 2003).

2.2 Early Childhood Education of Deaf

The methodology for early childhood education of the Deaf (Felipe, 2000), the main basis for the set of guidelines presented in this paper, is mainly based on the concept of semantic triples. This means that for each semantic field (e.g. food, transportation, animals) there is an element that matches the word in Portuguese, the sign in Libras and a corresponding picture in fruitful physical education practices. This was the basis of the methodology being followed. With it, the student gets to know the vocabulary of the topics with which he/she has or will have frequent contact. The vocabulary is needed for further linguistic achievements.

This methodology can be used in various game genres such as action games, adventures, puzzles and even sports. For example, on a side-scroller platform game, the student/player would be required to find the 3 elements (Libras, Portuguese and visual representation) related to a given concept in some stage before being allowed to proceed to the next level.

Another possibility that the methodology addresses is games that allow the fitting of the letters of the alphabet with the letters shown in Libras (fingerspelling). This fingerspelling is used by the Deaf to refer to proper names and to words that have no corresponding sign in Libras. Such an approach could

be adopted in the early [and easier] stages of a game, and only in the later stages the game could offer the semantic triples.

3 THE GUIDELINES AND THE MODEL

Hearing children have little or no difficulty in playing and understanding current video games and, if they face any difficulty, there are tutorials and tips for them in text or voice in their language. Deaf children, on the other hand, can not take advantage of such assistance, because most of them do not understand the written Portuguese, nor can they hear the voices of narrators. This reveals a great research question: **How to make games suitable for deaf children?**

Associated with this issue, there are all the benefits of the use of computer games in education. Therefore, in addition to understanding how to develop video games for Deaf children, another relevant question is: **How to create educational video games for children of these communities?**

3.1 Methodological Steps

The two questions in the preceding paragraphs have directed the whole work. All the methodological steps pursued are described in the following paragraphs.

Common guidelines between the recent studies (Korte et al., 2012) (Song and Zhang, 2008) (Ibrahim and Jaafar, 2009) in the field of Educative Games were accepted and incorporated on the model right away. When guidelines were not consensual among all the papers, the ones that met the requirements of Education of Deaf were included.

The core structure of an educational Deaf children methodology (Felipe, 2000), previously developed and tested by an expert at this matter, was used to build the specific guidelines that concern the Deaf children. The association between this structure and the educative games models oriented the creation of the new guidelines this paper proposes.

Most of the general guidelines for the construction of educational software games can be applied in the context of Early Childhood Education of Deaf. However, when there were inconsistencies between the identified general guidelines for educational games and specific methodology of early childhood education of Deaf, scientific papers involving Deaf games that meet the guidelines of educational games such as (Melonio and Gennari, 2013) were used as decision arguments.

3.2 The Proposed Guidelines

This subsection lists and explains all the guidelines created. The guidelines are ordered taking into account the sources that supported their creation, i.e. if the guideline is based on educational games models, Deaf education or general Deaf games. Each guideline presented is also followed by an example, often based on real games, that makes its understanding simpler and easier.

Based on the previously discussed main models of educational games design accepted in the scientific community, the following guidelines were suggested for the design and implementation of educational games for the Deaf:

G1: When planning an educational game, it is necessary to first define what the designer/pedagogue wants to teach in the game. E.g. if the game is going to teach greetings and farewells, this is the first thing that must be decided in the game making.

G2: After defining the learning goal, the target audience and its age must be specified. This has several reasons: adequacy of the interface with animations and graphics appropriate for the players' age, use of language easily understood by the target audience, defining the scope and depth of content, among others. E.g. in a puzzle game some cognitive tasks can not be performed by children below certain ages.

G3: The genre of the game being developed should be chosen to suit the target audience and the content being taught. E.g. the developer should not build a RTS or FPS game for a child. The educational effect would be lost within the game complexity.

G4: The objectives need to be clear and have direct association with the teaching of the desired content. E.g. matching illustration or animations with the content being taught.

G5: The games must contain tutorials on how to play them. An educational game will have no educational way of teaching a certain subject if it is not even able to teach the player how to use it. E.g. a brief video with the basics in the beginning of the game play.

G6: The feedback for the players' actions must always be as fastest and as understandable as possible. E.g. when an error is committed, the screen reaction must be fast and understandable.

G7: In addition to the feedback system, a system of player evaluation and performance record is required. E.g. some kind of score system that records the players successes and flaws.

G8: The evaluation system needs to have meaningful grades or quantifiers. E.g. numbers, coins, hearts, bars, etc.

G9: The interface elements must not distract the

student's attention away from its main task. E.g. score system, hints, close or back buttons, they all must be discrete.

G10: The difficulties and challenges must be present in the gameplay tasks, not in use of the software interface, which needs to be as simpler as possible. E.g. the interface environment for some games like *The Sims* have so many objects in it, that using it is harder than actually playing the game.

G11: The game needs to offer levels of difficulty or have automatically adaptive difficulty according to the player's performance. E.g. usually the options of Easy, Medium and Hard difficulties are enough.

G12: Whenever the game provides the player with complex tasks, it should part them into simpler tasks. E.g. if the objective of a certain level is: to get to the end of level, keep the health of the character up to 70% and collect 12 apples. These 3 goals should be split and carefully informed to the player during the level in order to make it feasible for the player.

G13: Customization is an useful feature, as players learn more easily when information is tailored to their preferences. E.g. allowing the player to choose the color of the character's clothes or the cursor of the mouse.

G14: In order to maintain the interest and attention of the players, the rewards should be delivered at the appropriate times. E.g. they must not be too frequent to the point of making them less desirable, but should not be too remote to the point of letting the player bored.

G15: The workload required for receiving rewards should be increased over time, as the player's skill also increases with playtime. E.g. in order to get an extra life for the main character, in the first level the player is required to collect 4 apples. In a latter level the number of apples needed should be the double.

G16: The game must offer one task at a time. E.g. beat the enemy, collect an apple, climb up a stair, etc.

From the methodology of early childhood education of Deaf the following guidelines are proposed:

G17: The game needs to incorporate elements that associate the written language with an illustration. E.g. taking advantage of the visual features of a game like graphics, pictures, animations, the language should have an element in the game that associates written Portuguese with some figure that explains the concept.

G18: In the cases of younger children (less than 4 years old), preference should be given to games that associate signs of Libras with illustrations, leaving the Portuguese aside. E.g. a point-and-click game that shows the word in Libras when the player clicks an

object, should forget the Portuguese for younger children and just show the Libras signs.

G19: Either the most basic levels or for younger children, levels or activities that associate the graphemes (letters) with the signed alphabet in Libras should be offered. E.g. a matching game that fits the letter A with its correspondent sign in Libras.

G20: Educational games for deaf children should be constructed from semantic triples (Portuguese, Libras and illustration), especially when the children's age is more than 4 years old. E.g. a space shooter that requires the player to destroy an asteroid which has the word in Portuguese, an asteroid which has the word in Libras and an asteroid with a picture of the corresponding object.

G21: Games should not always be focused on teaching Libras, but in teaching subjects that are relevant to the human development of the child. E.g. animals, transportation, hygiene.

The guidelines above are often overlooked in papers of educative games that have no participation of experts in education for Deaf.

Finally, from general guidelines of games for Deaf, the last guidelines that compose the set are the following:

G22: Texts should be avoided, since Portuguese is not the primary language of Deaf children. For older children or for literacy purpose games, this guideline might be avoided. E.g. video tutorial, animations and icons in every buttons, etc.

G23: The interface needs bold and bright colors to please the children, always highlighting the main task. E.g. the main activity of the game must always be in the center of the screen and with the brighter colors.

G24: Texts should not have unknown or ambiguous words, moreover, there is preference for the use of short words. E.g. if really necessary, the words in a button or in an interface element should be VERY simple.

G25: Relevant information must contain animations and highlights in order to draw attention of the child. E.g. always keep the game action to the center of the screen and always highlight objects that have relation with the main task.

G26: Instructions should be placed before the start of the game. Instructions that need to be inside the game should be placed in a separate area on the screen. E.g. a video tutorial that plays automatically when the game is about to start.

G27: Younger children should have less choices than the older ones. E.g. games that target ages from 2-6 should have little decision-making and should guide the player through constant hints and path high-

lights.

G28: The interface needs to be consistent, i.e., keeping the same items in the same order at different screens. E.g. the button to close the game should always be in the same place, no matter which screen the action is at the moment.

G29: Objects from the sides need dynamic and shapes that do not distract the player from the main task. E.g. static buttons for side options and less colors in the side interface components.

G30: Objects can only have mobility if they have relationship with the main activity. E.g. avoid moving/animating the assisting side objects like scoring system or hints.

G31: The feedback type must be customized for Deaf children. E.g. there is no point in using audible feedback, it should be animation or vibration on the screen.

3.3 The Model

In order to arrange the knowledge produced and facilitate its understanding, the following model combines the elements that compose the work developed. Figure 1 shows the model proposed.

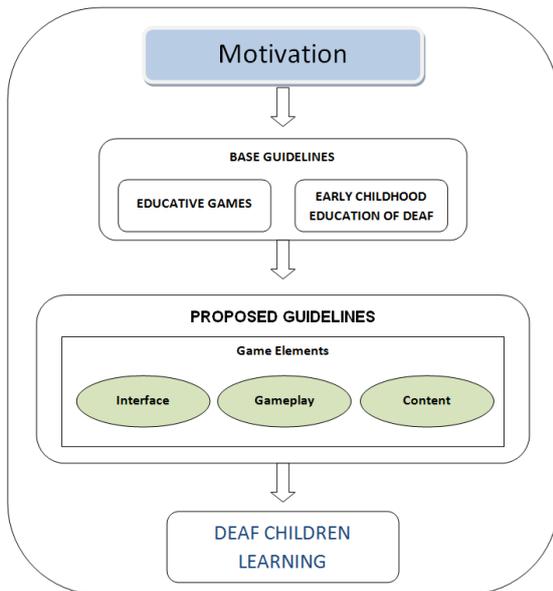


Figure 1: Model for Educational Games for Deaf Children.

The main inputs for the creation of the guidelines proposed were Educational Games models and the Methodology of Education of Deaf. The foundation of the whole structure is the Motivation. The motivation is the main component of any effective teaching. At the bottom of the model lies the result achieved with this work: early childhood education of the Deaf.

The main contribution of this work lies in the proposed guidelines. It is possible to organize each of the guidelines of the previous subsection in three categories: the ones that relate to the interface environment, those that deal with the gameplay mechanics that make up the game, and the ones that address the educational content included. Table 1 separates the guidelines according to the game components they correspond.

Table 1: Guidelines Classification.

Interface	Gameplay	Educational Content
		G1
G2	G2	G2
	G3	
G4	G4	
G5		
G6		
G7	G7	
G8		
G9		
G10	G10	
	G11	
	G12	
G13		
	G14	
	G15	
	G16	
	G17	G17
	G18	G18
	G19	G19
		G20
		G21
G22		
G23		
G24		
G25		
G26	G26	
G27	G27	
G28		
G29		
G30		
G31		

4 THE GAME DEVELOPED

4.1 Game's Description

To demonstrate the guidelines effectiveness, we developed a jigsaw puzzle game for education of Deaf



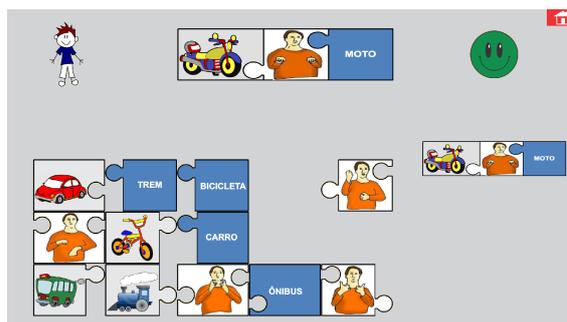
Figure 2: Screen of Theme Selection.

children. The game was developed in Python programming language in association with Pygame, a set of libraries for game development in Python. In the game's interface and interaction environment, the recommendations suggested in the guidelines were followed.

Figure 2 shows the theme selection screen. There, the player or the instructor decides which topic will be studied and played at the moment. Currently the game offer the themes: Animals, Food, Hygiene and Transportation. All topics were suggested by an expert in the field of early childhood education. Also these topics are relevant for the age of the target audience. Figure 2 also shows the absence of written texts and the use of bold colors, as suggested by the proposed guidelines for little children.

Figure 3 illustrates the game running in the theme *Transportation*. The presence of the semantic triples can be perceived. All the illustrations have fitting spaces, this way the student can match the correct sign in Libras, the word in Portuguese and the figure representing the concept. Triples already assembled successfully by the student go to the right side of the screen, in a smaller size, so the player can revise them if necessary. This also frees spaces on the board, allowing the player to stay focused in the incomplete triples. The game also offers a level of harder difficulty, that has no fitting borders around the figures. At this harder level the student has to match the triples with his own knowledge of Libras and Portuguese. Also, in the top left corner, there is the figure of a little boy, that corresponds to the game's evaluation system: as the player successfully matches the triples, the little boy starts receiving clothes pieces and colors.

As the guidelines demand, the game also includes a tutorial, which intends to teach the player how to properly play and react to the feedbacks the game provides. The tutorial is a 3 minutes length video that shows all the possible interactions the student may have with the game and the results he gets from each of them. The student can start the tutorial before choosing a theme and begining playing.

Figure 3: Game - *Transportation* Theme.

4.2 An Experts' Preliminary Evaluation

As a preliminary evaluation, the description and the executable file of the game developed were presented to an expert who agreed to participate in the process and give his opinion on the quality of the game. Our hypothesis was that provided the game proved to be satisfactory, so would be the guidelines that had led to it.

The report from a researcher of Human-Computer Interaction of another Brazilian Federal University is as follows:

"The menu is intuitive, the use of figures refers to the existing options. The two game options (with or without the matching pieces) are easily understood. The images have backgrounds that contrast with the drawings. The scorer of the total number of hits is understandable and the positive or negative that indicate whether the task was completed successfully or not is also satisfactory. In either game mode, after finishing the activities, it is not so clear that the player must click the icon of the 'door' in order to return to the main menu and play again. At first, one can remain waiting some other game instruction after the image of 'Congratulations'."

This report shows that the game was rather proper, following most of the guidelines. As some examples, we can quote the guidelines G6 and G31 that address feedback issues or guidelines G23 and G25 that cover colors and highlights.

Never-the-less, one critical problem was identified, referring to guidelines G9 - the 'Congratulations' picture distracts the player - and G10 - the task of going back to the main menu is harder than it should. Although this makes an author's mistake clear, for him not having completely applied his own guidelines, it also proves that those guidelines were correct.

4.3 A Case Study with the Game

The evaluation with Deaf children was held at the Mu-

nicipal School of Early Childhood Education and Elementary Education Geny Jesus Souza Ribas, a school specialized in the education of deaf children. After a meeting with the principal and the pedagogues, in which the game was shown and the process of assessment was discussed, the testing with the children was scheduled.

The assessment of the game was a qualitative analysis. Two 3 years old deaf boys took part in the tests [both about to turn 4 years old]. Besides them, an pedagogue, a hearing instructor fluent in Libras and three Deaf instructors assisted the assessment.

The students showed great joy with each successful match they made in the game and also every time they initiated a new game. During the first 20 minutes of play, the children needed constant help from the instructor. After that time, they began to play alone and solve the problems without help, this occurred with both children.

The software had a feedback that alerted the player when he did something wrong, but the feedback didn't show, at the time, which mistake had been made. From this pertinent remark put by both participants, the tool was revised and improved with a more informative and precise feedback. An interesting comment is that both boys showed enough level of satisfaction with the game and came out with the same unique complaint. This fact illustrates a differential feature of qualitative exploratory testing: the discovery of especially good and/or especially bad characteristics of the assessed artifact.

5 CONCLUSIONS AND FUTURE WORKS

The main contribution of this work lies in the guidelines for building computer games with the purpose of early childhood Deaf children education. From the knowledge presented in this paper, a set of guidelines were created, in order to guide programmers, game designers and game development teams as a whole in the construction of educational games for the target audience.

The knowledge generated was then used in the development of an educational game for teaching Libras for Deaf children ranging from 0 to 6 years old. The software product was tested with two children. The game will soon be offered for free to all schools that have Deaf children students in their classes.

As future work we intend to develop a collaborative authorship tool that helps teachers and game designers in the gathering of materials like images, games levels, etc. These materials can be used

in several games and the tool will also guide the teacher/designer in the development of educative games for Deaf children.

ACKNOWLEDGEMENTS

We wish to thank CAPES foundation and the Reuni program for granting the scholarship that made this study possible. We also want to thank professors Adriana Vaz, Francine A. Rossi and Andrea F. Andrade for the authorship of artistic drawings of the interface.

REFERENCES

- Alves, L. (2005). *Game Over: Jogos Eletrônicos e Violência*. Ed. Futura.
- Amory, A. and Naicker, K. (1999). The use of computer games as an educational tool: Identification of appropriate game types and game elements. volume v, 30, pages p. 311–321. *Journal of Educational Games*.
- Antunes, D. R. (2011). *Um Modelo de Descrição Computacional da Fonologia da Língua de Sinais Brasileira*. UFPR.
- Barab, S., Thomas, M., Dodge, T., Carteaux, R., and Tuzun, H. (2005). Making learning fun: Quest atlantis, a game without guns. In *Journal of Educational Technology Research and Development*, volume v. 53, pages p. 86–107. Kluwer Academic Publishers.
- Bourgonjon, J., Valcke, M., Soetaert, R., de Wever, B., and Schellens, T. (2011). Parental acceptance of digital game-based learning. In *Journal of Computer Education*, volume v. 57, pages p. 1434–1444. Elsevier Science Ltd.
- Bueno, J. (2014). *Pesquisa Ação na Construção de uma Solução Conceitual de Apoio ao Letramento Bilíngue de Crianças Surdas*. UFPR.
- Costa, D. N. d. (2012). O uso de jogos no ensino de língua estrangeira. volume v. 3, pages p. 1–17.
- Felipe, T. A. (2000). Metodologia para o ensino de libras para crianças surdas. XV Encontro Nacional da AN-POLL.
- Guimarães, C. (2013). *Arquitetura Pedagógica Computacional para Interações entre Crianças Surdas e Pais não-Surdos em Libras e Português*. UFPR.
- Ibrahim, R. and Jaafar, A. (2009). Educational games (eg) design framework: Combination of game design, pedagogy and content modeling. pages p. 293–298. *Electrical Engineering and Informatics International Conference*.
- Korte, J., Potter, L. E., and Nielsen, S. (2012). Designing a mobile video game to help young deaf children learn auslan. In *Proceedings of the 26th Annual BCS Interaction Specialist Group Conference on People and Computers*, pages p. 345–350. British Computer Society.

- Laranjeira, P., Porto, E., and Alves, L. (2011). Garena e dota como plataformas digitais de comunicação para usuários de jogos. SBGAMES.
- Melonio, A. and Gennari, R. (2013). How to design games for deaf children: Evidence-based guidelines. 2nd International Workshop on Evidence-based.
- Pereira, T. (2007). Reflexões sobre a potencialidade dos jogos eletrônicos nas aulas de língua inglesa: Contribuições atingidas. pages p. 1–8. UNIPAN.
- Prensky, M. (2003). Digital game-based learning. volume v. 1. Computers in Entertainment.
- Schroter, B. A. F. (2004). *O Jogo e o Ensino de Línguas*. UFSC.
- Skliar, C. (1999). *A Surdez - Um Olhar Sobre as Diferenças*. Mediação.
- Song, M. and Zhang, S. (2008). Efm: A model for educational game design. pages p. 509–17. Technologies for e-Learning and Digital Entertainment.
- Squire, K. (2003). Video games in education. *Int. J. Intell. Games & Simulation*.
- Squire, K. and Jenkins, H. (2003). Harnessing the power of games in education. volume v. 3, pages p. 5–33. *Insight*.
- Virvou, M., Katsionis, G., and Manos, K. (2005). Combining software games with education: Evaluation of its educational effectiveness. volume v. 8, pages p. 54–65. *Journal of Educational Technology & Society*.