An Evaluation Method of Educational Computer Games for Deaf Children Based on Design Guidelines

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Abstract. Computer games have been used for a long time as a valuable tool in the teaching and learning of a variety of subjects. The Deaf communities and in particular the Deaf children have different learning needs compared to hearing children. For this reason, there have been, even timidly, some educational games that focusing on such children. However, as these games do not have a standard methology for development, they usually do not meet the needs of the target audience. Therefore, this paper proposes a method for evaluating the quality and suitability of existing educational games for Deaf children through a tested set of design guidelines for Deaf children games. Two computer educational games for Deaf are evaluated. In addition, after the evaluation, a case study is presented to demonstrate the redesign of a game based on the guidelines and the results obtained.

Keywords: Human-Computer Interaction · Deaf culture · Social inclusion · Computer games · Educational games · Education of deaf children

1 Introduction

Deaf communities live today a historical period of assurance for social rights, which were denied for them for at least a century [2]. One major right that has been recently granted is the use of Sign Language. The Sign Language is an important component of the Deaf culture, characterized by a visual-spatial form [1]. Sign languages are the natural languages for the Deaf, they are complete language system with lexicon, syntax, and ability to generate an infinite set of sentences [3].

Even with current advances, the need for computational tools to assist the Deaf in communication and access to information is clearly noticed [4,5]. One useful computational tool that is lacking for the Deaf is quality computer educational games. Adequate educational games for Deaf children are games that

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communicate mainly through sign languages with the user while also teaches some knowledge area to the player.

There are few specific games for Deaf children, and some of them do not have all the requirements/characteristics necessary for the target audience. This leads to the question: **"What is missing in these games for effective success?"**. If the answer to this question if found, the development of inappropriate educational games can be avoided, and also the improvement of existing games can be supported.

1.1 Motivation and Goals

The work [6] presents an exploratory study for guidelines that support the design (creation of new games) of educational computer games for Deaf children. Such work considers the gameplay, language and interface needs that the game must attend to. The guidelines creation is based on an effective methodology for teaching Deaf children, as well as reputable models for development of general educational games.

This paper's motivation is the evaluation of existing educational computer games, in order to improve their quality and suitability for Deaf children. Therefore, this article intends to use the guidelines of [6] as a quality inspection method of existing digital games.

As contributions, this study presents the adequacy of the guidelines as an inspection method, the evaluation results of two games, and a case study of the improvement of an educational game. In addition, self critical analysis of some guidelines are pointed out.

The remainder of this paper is as follows: Sect. 2 discusses the subject of digital games, from general video games to educative games for Deaf children. Section 3 presents the guidelines used in the process of games evaluation for Deaf children. Section 4 shows the evaluation process proposed. In Sect. 5 a case study with one game is performed. Finally, Sect. 6 concludes the paper and discusses future works.

2 Computer Games

Digital games have become a major entertainment area today. They have a way of immersing players into an epic challenge that consumes them physically, intellectually, and emotionally. There is no denying the fact that children and teenagers love computer games [7]. The development of computer games involves professionals from various areas however, an important part of its development lies with the Computer Science professionals.

Just as in the film industry, there are several genres in the industry of games currently [8]. These genres serve both to guide the consumer at the time of purchase, and to guide the team in a direction of development. One sub-genre of games are the educative games. These kind of games have the purpose to teach some field of knowledge in a playful manner.

2.1 Educational Games

Studies such as [9,10] show that digital games not only satisfy the entertainment needs of children, but also contributes to the cognitive, social, emotional and cultural development. Added to these benefits of general computer games, the educational game has the potential to teach relevant contents to the player.

Despite all the benefits the educational games can bring to children, the design and development of educational games with authentic learning content while also keeping the user entertained, can be quite challenging [11]. Not everything that is called 'game' is fun and motivating, the game design needs to be well prepared to ensure these qualities. The educational games should include good game design and good pedagogy in order to ensure the effectiveness of learning [11].

The educational game can not only be considered as a kind of educational media, but also as a learning environment to study, because the game itself contains the basic elements that are needed in learning activities [12]. Educational games are embedded within the concept called Educational Software, important concept of the field Education Informatics.

2.2 Games and the Deaf

There are works that address the development of digital games for the Deaf. The works [13–15] deal with the development of a game for American Sign Language (ASL). The work [16] shows the creation of a mobile game for Deaf children to learn Australian Sign Language (Auslan). The common problem found in these works is the fact that the developed applications are more interactive software than digital games. These applications lack many gameplay elements such as clear goals, score, completion of stage, to be fully characterized as games.

There have been attempts to make contact with the authors of the papers from the previous paragraph, in order to apply the guidelines for evaluating their games. However, the authors did not respond the contact attempts. Since there are few academic papers on games for Deaf children and the access to the executables of the games from the published papers [13–16] was not possible, a decision has been made to evaluate two educational games present on web sites for children educational games,[1] instead.

3 Guidelines

As previously pointed out, the study that serves as base for this one, created a set of guidelines in order to guide game designers and developers into making effective educational games for Deaf children. The design guidelines contain rules that should be followed in the development of a game to make it suitable for Deaf children education.

[1] http://www.educajogos.com.br/jogos-educativos/alfabetizacao/. http://www.atividadeseducativas.com.br/index.php.

A new possibility that has been perceived in the set of guidelines is to asses the quality of a given educational game for Deaf children. Most likely, the educational games already developed for Deaf children did not follow the set of design guidelines, since they were created in a recent work. In this sense, it is possible to assess the suitability of educational games and point out possible improvements using these guidelines as tools.

3.1 Conception Methodology

The design guidelines used, as foundation, respectable educational game models and a methodology for education of Deaf children. The construction process of the guidelines was carried out as follows: When intersections between the guidelines in the most important studies of educational games were found, these were incorporated immediately. On the other hand, when the guidelines were not consensus among the main papers of the area, those guidelines that attended the Deaf education were followed. When there were guidelines that, although consensus among the models studied, did not fit in the situation of Deaf people (e.g. guidelines directing sound feedback or guidance on the game music), they were discarded and not included in the set.

3.2 Classification

There is a total of 31 guidelines. Each of them can be classified corresponding to the game element they relate to, that, is the Interface, the Educational Content and the Gameplay. Figure 1 summarizes this structure.

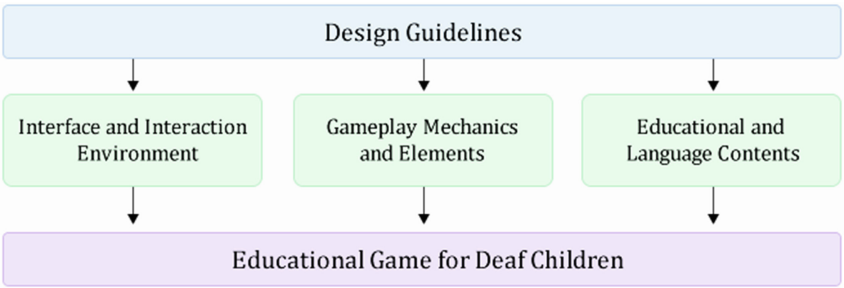

Fig. 1. Guidelines classification

Any educational game for Deaf children can be summarized in these three game components. Some of the guidelines have responsibilities that cross over those sections. Some examples of guidelines will be shown in the next subsection.

3.3 Pratical Examples

Next an example of each type of guideline is presented.

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.

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.

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.

4 Games Suitability Evaluation

As mentioned in Sect. 2, two games from Brazilian educational games websites were used for the evaluation process.

The first one is a game that trains fingerspelling and word construction. The game shows a picture of a given concept and asks the child to construct the word, letter by letter, that names the concept. It teaches simultaneously Libras fingerspelling and the written alphabet. The game has two levels of difficulty: the easiest has a table containing the alphabet in Libras and the written alphabet, the second and more difficult mode does not have any auxiliary tool. Figure 2 shows a screenshot from the game play.

Fig. 2. Game 1 - Figure and fingerspelling match

The second game belongs to another website of games for Deaf children. This game asks the player to combine the figure of an animal (to the right of the screen) with the figure of a child signaling in Libras the animal's name (in the left side of the screen). Figure 3 shows the game in execution.

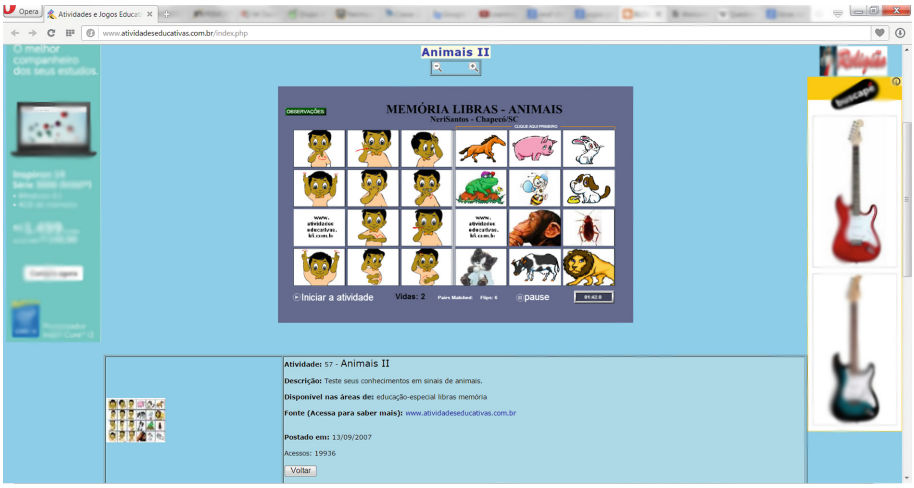

Fig. 3. Game 2 - Animals' names in libras

4.1 Process Methodology

The process of evaluation took place at the Human-Computer Interaction laboratory of Federal University of Paraná. The technique used was "heuristic" inspection by experts. Each game was played for 30 min. Then, every guideline from the set was checked, in order to see if the game fully meets, partially meets or does not meet the guideline, or yet if the guideline is not applicable in this kind of game.

Checklist Structure. The main tool used in the evaluation process was an organized checklist. It basically consists of a system that shows in order: a guideline, a guideline example of use and, finally, the question of game about the presence of the guideline in the game. The question checks whether the educational game meets, partially meets or does not meet the guideline or if the guideline does not apply to the game under evaluation.

Figure 4 shows an example of guideline verification. The complete checklist can be publicly accessed online[2], it can be used by anyone that intends to test an educational game for Deaf children.

[2] http://goo.gl/forms/N9H8tdhCuh.

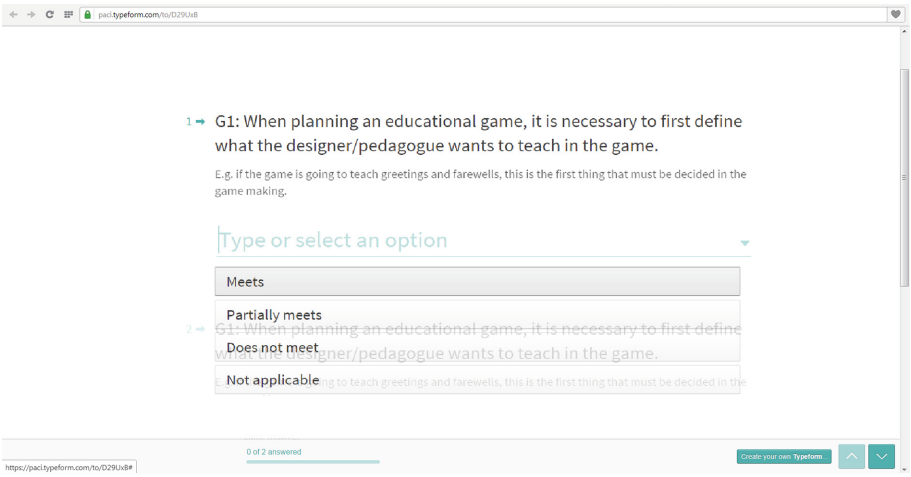

Fig. 4. Main evaluation tool - Checklist

4.2 Evaluation

In order to observe effective pratical results, the obtained data generated three graphs for each game. The graphics correspond to the quality of the graphical Interface, the Educational content and Gameplay of the game, based on the guidelines. Figure 5 comprises the graphics generated in the process.

The results are given according to the number of guidelines the games attended. In cases of non applicable guidelines, these were not counted in the final assessment of the game. The game's performance is fair according to the guidelines that fit to it, non applicable guidelines have no negative impact on the game.

Some problems encountered in the games can be easily perceived by any user. For example, the Guideline 29 states that "Objects from the sides of the screen need dynamic and shapes that do not distract the player from the main task", this guideline is missing on both games, since they are browser-based games from free websites and the sides of the screen are full with advertisements that distract the player's attention.

The analisys of the results shows that both games met the requirements regarding the educational contents. The major issues were with the interface environment, which showed poor results on both games. The gameplay is also a large problem in the second game, as well.

The interface problems can maximize the user learning curve and create difficulties for the user to achieve the game's objectives. In this context, the user may feel frustrated, may not understand the rules and forms of interaction, among other problems. For example, in Game 2, a major problem seen in the interface is the use of terms in English, it is already hard enough for a Deaf children to read in Portuguese, adding English to the interface makes it even worse. The main interface problem of Game 1 is an easily solvable one. The problem is the

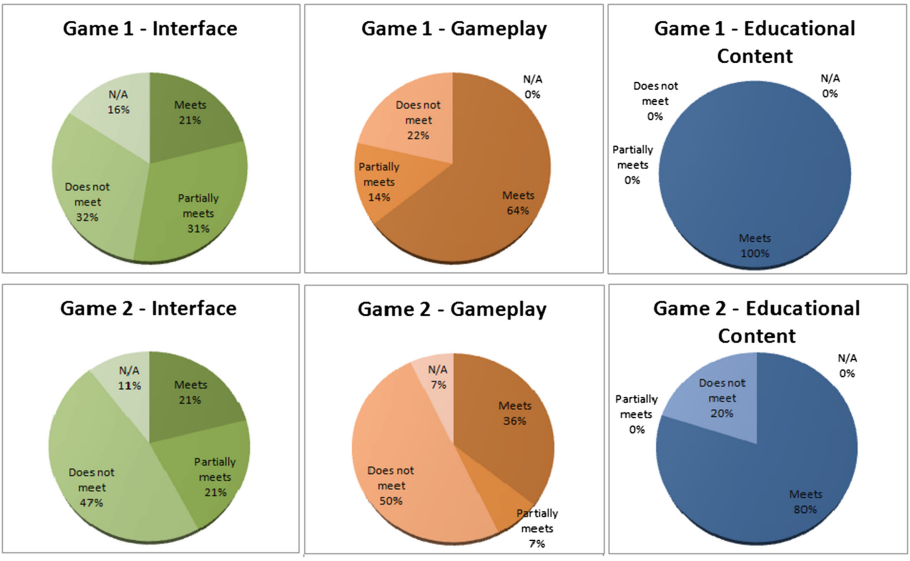

Fig. 5. Main evaluation tool - Checklist

inappropriate positioning of the playable part, which is not centralized, thus losing highlight and possibly diverting the attention of the user.

Gameplay problems tend to remove the potential for fun/motivation of the game. Furthermore, such problems may causa the player to lose interest and, in more severe cases, even irritate them. For all these reasons, it is very important to guarantee a good gameplay in educational computer games. For example, in Game 2, the player needs to choose some picture in the right side of the screen, before selection one in the left side, that is totally unnatural and can cause confusion to the player.

5 Case Study with Game

The previous section showed an evaluation analysis of educational games and the viability of the evaluation process based on design guidelines. However, these results should be used to adequate the game for the users, with the application of the guidelines. Thus, this section presents a case study to correct a educational game based on design guidelines and their new results when applied.

The game consists of a puzzle in which the player needs to fit the pieces referring to the figure of a concept, the signal in Libras and the word in Portuguese. The player fits pieces from geometrical figures on their edges, simulating the fittings of a puzzle. Each time the player hits a set of elements, the set, is moved in smaller size, to the right of the screen, freeing up space on the board for the remaining pieces.

The game features themed levels, based on important concepts to children as Food, Transportation and Hygiene. The choice of the level is made by the player before starting the match. After fitting all the pieces of figures, the level is complete. Figure 6 shows a screenshot from the game in the theme Food.

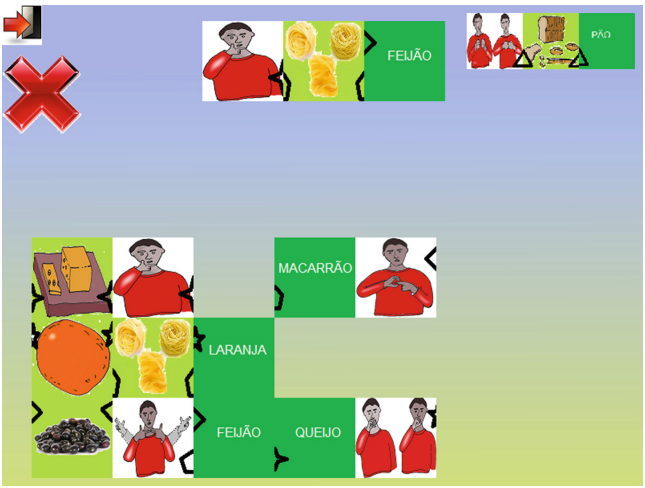

Fig. 6. Puzzle game of case study

For this game, just like the two games of the evaluation process, each guideline was checked in order to see if it was met, partially met, not met or not applicable. For each guideline that was partially met or not met, an adjustment to the game was made. The changes made are listed next:

- Guideline 4 states that the game's objectives need to be clear. Since the shaped pieces did not have resemblance to puzzle, they were changed into more adequate puzzle pieces.
- Guideline 5 says the game needs to have a tutorial for teaching the players how to play it. The game did not have one, so a video tutorial was recorded, showing how to play the game and how to react to the game's feedbacks.
- Guideline 7 concerns player's evaluation system, the game had no feature like that. In the improved version, an evaluation system consisting of a boy that receives clothes pieces when the player successfully matches the sets was inserted.
- Guideline 11 says the game needs to have difficulty levels. Two levels of difficulty are now present in the game: one with shaped pieces, one (harder) without it.
- Guideline 23 relates to interface colors and highlights. All the colors of the game were reworked in order to be more adequate to children.
- Guideline 28 concerns interface consistency. In order to guarantee it, all of the buttons and options in the interface have been renovated.

– Guideline 31 states the feedback must be adequate for Deaf children. To do this, the visual feedbacks for right, wrong, selected button, level complete were improved.

5.1 Game Improvement

After the application of the guidelines and a visual makeover, the game became more suitable for the education of Deaf children. Figure 7 contains a screenshot from the renewed version of the game.

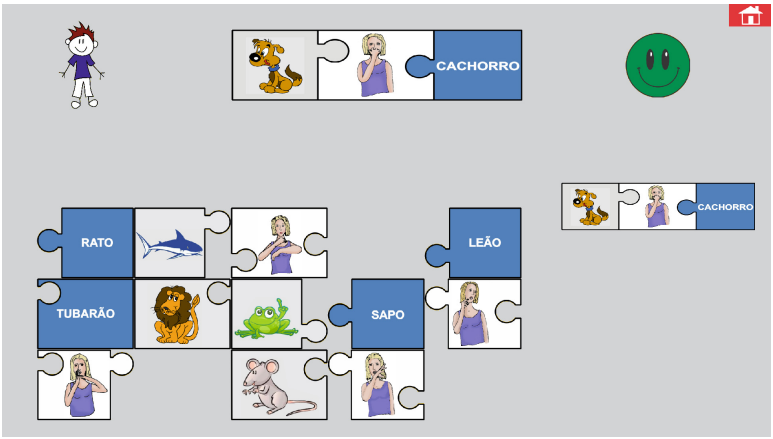

Fig. 7. Puzzle game of case study - After the guidelines application

6 Conclusions and Future Work

The application of the guidelines as an inspection tool was satisfactory. As a result of the tests, it was possible to identify points for improvement of existing educational games. This is a positive result, it is better for a developer to fix or to improve a game already developed, rather than developing a game from scratch. The improvement/adjustment can be made in a shorter time interval.

In the case study, with the improvement of the game based on the guidelines, the tool also proved suitable. The game has undergone many modifications. It is possible to see the significant evolution experienced by the application after the use of the guidelines.

Since the checklist's target audience are designers and teachers, a possibility of future work would be to adapt the checklist to other target audiences, for example, the users himself, in checking the quality of their games. Another possibility, would be having smaller checklists to evaluate each part of the game (interface, content and gameplay) separately.

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