Redesigning towards accessibility: from a Facebook trivia game to an educational, accessible web game

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Figure 1: *Diversão com números* screenshots: title screen (left), gameplay (center) and tutorial topics (right).

ABSTRACT

Popularity of web browser games has increased over the years mainly because of popularization of social networks. Since Web represents a large and an important interaction environment and since accessibility recommendations and guidelines for Web platform are well defined, it is necessary to provide accessible browser games so that entertainment and opportunities are available for all. This work purpose is to present evolution of an accessible educational Web game based on redesign and recreation of Facebook trivia game. The process includes information architecture design, paper prototyping, usability and accessibility evaluation by experts, and user testing. Preliminary results include comparing usability and accessibility of both versions (original and recreated) as well as description of challenges and decision-making related to accessible Web game design.

Keywords: Digital games, educational games, accessibility.

1 INTRODUCTION

Digital games are gaining ground nowadays and foster technology advance and wide Internet connectivity. This profitable market has caused an increase of nearly 600% [15] in the number of game development companies. In Brazilian scenario, for example, "In 2008, we had 43 game companies in Brazil. In 2014, this number has grown to 130. In 2017, there are about 300 game companies in the country." [15].

Also, according to Qualman [11] cited by Cheiran [5], "digital games on social networks (which usually runs in browser on web pages) help to increase their popularity since Facebook, Google+, MySpace and Bebo are responsible for about 80 millions of daily players". However, even though Web platform provides accessibility support [1] and social networks has reached remarkable accessibility levels [10], the great majority of games on Web are not accessible to all players.

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Since digital games provide many benefits to human development [8], web game companies should supply social networks with accessible games. It is specially desirable for educational games or trivia games that could be used with educational purpose.

The goal of this paper is to present the redesign process of Math Minute trivia game[1] towards an educational, accessible web game and to compare original version of the game and redesigned version considering accessibility.

This paper is organized as following: section 2 introduces game accessibility concepts and guidelines; section 3 details techniques and material used along game redesign, development and evaluation; section 4 presents features of the original Math Minute game, early game redesign to better fit educational purposes, procedures and results of Participatory Design with children for game information architecture, evolution of design and accessibility evaluation processes; and finally section 5 describes limitations and future work.

2 ACCESSIBILITY ON WEB GAMES

"Game Accessibility can be defined as the ability to play a game even when functioning under limiting conditions. Limiting conditions can be functional limitations, or disabilities — such as blindness, deafness, or mobility limitations." [14]. Accessibility is not something easily noted by users that don't need it, because accessibility options are often features or contents that don't heavily disturb or unbalance the game [7]. But, despite the existence of guidelines and polices on web and game accessibility, it is still rare that game developers integrate accessibility throughout their web game design.

Many accessibility issues are caused by technology decisions, since many games are developed in ActionScript programming language targeting Adobe Flash Player platform. Even though Flash Player is not unaccessible *per se*, it's difficult to create content in compliance with accessibility support resources [3, 10] and web browsers do not run ActionScript scripts natively. In contrast, games created in HTML and JavaScript languages get better overall

[1]Math Minute is a game created by Imre Somogyi of DiliGames game team and it is available at https://www.facebook.com/games/mj-math-minute-/ and http://diligames.com/games/math-minute .

accessibility support and they can be run without additional plugins.

For games developed in HTML language, there are well established Web Content Accessibility Guidelines (WCAG) that guide the creation of web content that is "[...] accessible to a wider range of people with disabilities, including blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, photosensitivity and combinations of these" [1]. Its main document [1] is organized into four **principles** (perceivable, operable, understandable, and robust) to provide the basis for accessibility, twelve **guidelines** inside of principles to describe detailed goals of accessibility, one or more **success criteria** inside each guideline for conformance testing, and a wide variety of **sufficient and advisory techniques** to fulfill accessibility tests.

There are also specific accessibility guidelines for games [5, 7, 2]. While Cheiran's guidelines [5] are organized according WCAG 2.0 structure, guidelines of AbleGamers [7] are separated into four categories of disability: **mobility**, **hearing**, **vision** and **cognitive**. Each category contains guidelines grouped in one of three levels (it's not clear what each level means, but the analysis of common features suggests that level one covers more simple to fulfill guidelines than level three).

Guidelines available at [2] are organized in a similar way that [7]. There are three categories: **basic**, **intermediate** and **advanced** guidelines. Each guideline is placed into a category considering "number of people who benefit, the difference made to those people, and cost to implement" [2]. Each category also is subdivided into sub-categories related to disabilities: **motor**, **cognitive**, **visual and speech**, and also some **general** considerations that apply to all areas. Many detailed descriptions of guidelines are supported by hyperlinks with best practice examples to guideline compliance.

Despite the chosen guideline collection, it's important to consider that "guidelines are an umbrella set for all genres and mechanics. They won't all be relevant to your game, so first decide which guidelines are appropriate for your mechanic." [2]. Also, to follow guidelines is not enough to guarantee accessibility of a game, so "you also need to test your prototypes with disabled players, and research & seek advice when needed." [2].

3 Methods and Materials

The aforementioned Math Minute game developed for Adoble Flash Player platform was used as basis to our redesign process. Our accessible version of the game called (so far) *Diversão com Números* was developed using HTML5, CSS and JavaScript languages. No libraries were adopted in the project to minimize external accessibility issues.

NetBeans IDE [2] was used for coding and Atlassian Bitbucket [3] was used for version control in a Git version control system. Atlassian SourceTree [4] software supported version control. Game design decisions and tasks were organized at a online kanban board at Trello [5]. Additionally, Google Chrome native inspection and debugging tools supported verification processes.

Cheiran's game accessibility guidelines [5] and W3C's Web Content Accessibility Guidelines 2.0 [1] have driven redesign and implementation processes towards accessibility. Participatory Design (PD) [9] and Paper Prototyping [16] were applied at early game redesign with children.

NVDA screen reader [6] was adopted for accessibility testing during development and JAWS screen reader [7] was used during user testing. Test environment details are shown at Table 1. Accessibility test with user followed the same structure of usability test detailed by Rubin [12] and it was remotely conducted through Microsoft Skype.

Table 1: Accessibility test environments.

Development tests
Windows 10 operational system
Google Chrome web browser
NVDA screen reader 2014.4
Expert test
Windows 8 operational system
Mozilla Firefox web browser
JAWS screen reader 16.0

4 Game Design

Game Design completely defines a game by creating goals, rules and challenges and by detailing interface and aesthetics. According to Schell [13], it's essential to establish the game interface, since it is the match between gamer and game. In the redesign process of Math Minute game, most of original mechanics were preserved, but there are clear constraints related to accessibility that should be addressed besides usability improvements detected.

The traditional Game Design Document (GDD), which is important as memory and communication tool, were replaced by a kanban board at Trello to allow flexibility and to improve organization of tasks.

4.1 Original game: Math Minute

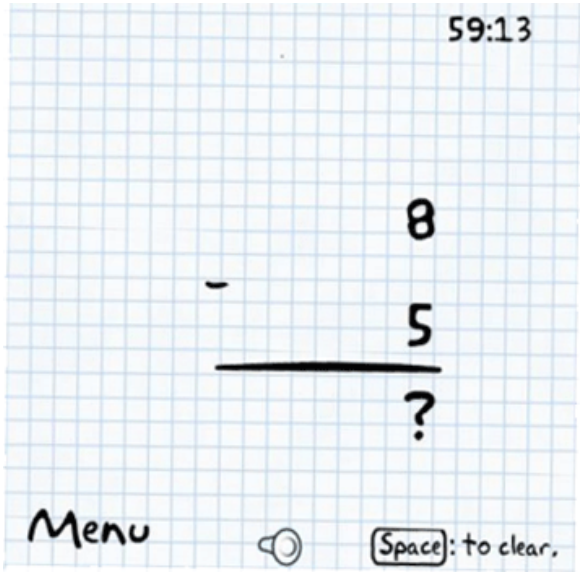

Figure 2: Original interface of Math Minute game.

The original Math Minute game presented at Figure 2 is a trivia math game in which the player shall solve as many as possible math operations (additions, subtractions, multiplications and divisions) in one minute. As player types numbers at the keyboard, the game starts to fill the solution for the operation. If the solution is correct, the game plays a sound and shows another operation. If the solution is incorrect, nothing happens and the player must press space bar on

[2] Available at https://netbeans.org/.
[3] Available at https://bitbucket.org/.
[4] Available at https://www.sourcetreeapp.com/.
[5] Available at https://trello.com.
[6] Available at https://www.nvaccess.org/.
[7] Available at www.freedomscientific.com/Products/Blindness/JAWS.

the keyboard to try another solution. Time counter is always visible at right superior corner. The only options available are disable the background music (centered at bottom) and **menu** text that return the game to title screen.

This version contains mechanics incompatible with many accessibility guidelines adopted in this work [1, 5]. Most critical violations include, e.g., (1) incompatibility with any screen reader, (2) impossibility of playing only through keyboard, (3) missing important graphic and sound feedback, (4) lacking of difficult selection, and (5) missing tutorial and help.

4.2 Paper prototype

In the first paper prototype [16] of the redesigned game presented at Figure 3, we evaluate game mechanics and their compatibility with accessibility recommendations. Based on this evaluation, we included improvements as (1) replacement direct typing the solution at keyboard by traditional HTML text field, (2) inclusion of graphic and sound feedback when time is about to run out (a watch character was included), and (3) possibility to exchange score points for more time.

Figure 3: Paper prototype of the first version.

4.3 Paper prototype evaluation and PD

Evaluation and evolution of first prototype was done in a public primary school with fifth grade students by using Participatory Design (PD) [9] which is "an approach that helps the designer to investigate and to better understand the relation of children with technology developed to their use by mutual collaboration". We presented the paper prototype, provide black paper and color pencils, and ask the students to change game layout to better fit their expectations.

In order to join the activity, each student should get the sign of his/her parents (or other adult responsible for the student) at a term of agreement and confidentiality. In addition, each student himself/herself should sign a simplified version of the same term and agree. Everyone who had not agreed to participate has received an alternate pleasant activity.

Participatory Design process last three hours, involved thirteen children, and followed the protocol below:

- (at the beginning) Recall terms of agreement and confidentiality.
- Address participant to each activity (Participatory Design or alternate activity).
- Tell PD participants to form small groups.
- (to each group) Thank participants to join the PD, show materials (blank paper, color pencils and pieces of the previously made prototype), explain the main idea of the game, and ask them to assemble prototype pieces together and replace anything they want to.
- Periodically remind children they can leave the activity anytime and without any consequences.
- Observe each group work and eventually ask questions to understand motivations and logic.
- Record results of each group through photos.
- (at the end) Thank participants again and drive them to regular school activities.

Changes made by children includes (1) moving game options to inside the blackboard (original evidence at Figure 4) to improve visual coherence and scholar context, (2) suggesting the use of all four arithmetic basic operations (since the prototype just included addition and subtraction examples in previously made pieces), and (3) insertion of many colors in the game to improve fun (original evidence at Figure 5).

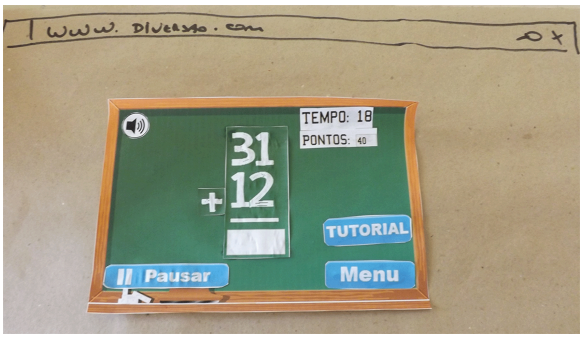

Figure 4: New layout suggested by children at Participatory Design.

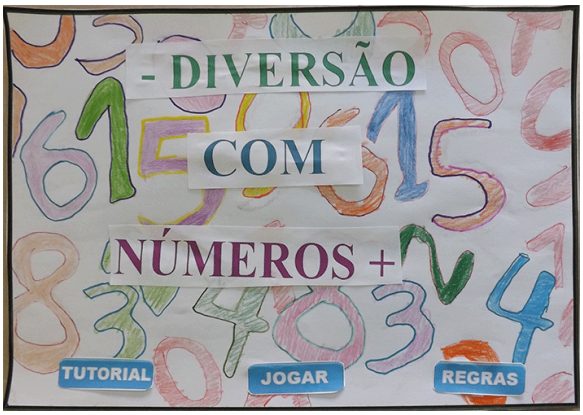

Figure 5: Background drawn by children at Participatory Design.

4.4 Digital version and early accessibility evaluation

Once contributions of children had been gathered and compiled, we started to build the digital HTML version (presented as teaser Figure at the beginning of this paper). Game mechanics and features were put on Trello as user stories [4] and tasks were assigned.

During development, manual accessibility verification processes were run by development team. Tests were supported by Google

Chrome native JavaScript debug tools and NVDA screen reader. Inspections were supported by Google Chrome HTML & CSS native inspection tools and by accessibility guidelines.

Manual tests were run periodically by development team and included, e.g., (1) performing every action of the game using keyboard only, (2) performing every action of the game using mouse only, (3) turning the monitor off and performing every action of the game through screen reader feedback only, (4) reading every text line to ensure it is legible and understandable, and (5) analyzing every image and non-text content to ensure suitable alternative text.

4.5 Expert evaluation

Since it is essential to include people with disabilities among testers, we performed an accessibility evaluation with a blind tester that is also an accessibility expert.

The remote test was conducted supported by a Microsoft Skype call and based on usability user testing protocol [12]. The user was oriented to think-aloud throughout five tasks performed at his own laptop computer. JAWS screen reader was used and test session took one and a half hour. After each task had been completed, the expert suggested improvements or solutions to detected issues.

Main accessibility issues not detected by development team testing and detected by user testing were (1) functions that incorrectly trigger when TAB key makes some elements to lose focus, (2) need to move focus to the first element of the screen when there is a screen change that doesn't reload the entire page (in this case, browser automatically reposition focus on first element), (3) bad alternative texts that need revision based on guidelines [6], (4) lacking of browser shortcuts (which, in fact, were previously disabled because of a minor bug), and (5) some game sounds doesn't truly help a blind gamer to understand the game state. All these issues are currently addressed to development team.

5 Final Considerations

Game accessibility is an important field that promotes the same opportunities to all players, and it is critical on social media games that play entertainment and social roles at same time.

Even though the reported redesign process had not achieved the final product, procedures and findings until this stage help designers and developers to understand challenges in integrating accessibility into web games. It is also visible the significant effort to redesign and to rebalance game mechanics planned without accessibility in mind.

Future work includes to fix accessibility issues and to redo user testing, to build automated unit tests with Jasmine framework [8] or another tool, to implement a developer mode at the game to allow the use of automatic accessibility validators as AccessMonitor [9], and to consult municipal education council from Alegrete, Rio Grande do Sul, in order to balance game content to our target age group (from five to ten years old).

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