Serious Game Design for Children: A Set of Guidelines and their Validation

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ABSTRACT: Digital games can be used as allies to support and motivate the learning process. Many researchers focus their studies on the so-called Serious Games (SG), which are games whose primary objective is not solely entertainment. What happens, however, is that these games end up being far from children´s expectations, especially when compared to entertainment-only games. Thus, this work reviewed the literature in search for positive experiences of developing and using SG for children. Afterward, they were compiled together as a set of guidelines that can be followed by designers and developers of SG for children, guiding the design decisions so that the final product would be better suitable to children. The set of guidelines was obtained through SG analysis of child-oriented and child technology recommendations, leading to a total of forty guidelines that are divided into four groups: input, output/interface, content, and control. They have been assessed by 59 experts which concluded that they were all worth attention when designing SG for children.

Keywords: Serious game, Game design, Children, Guidelines

1. Introduction

Some of the benefits brought by the use of games on education, besides the improvement of learning, are the motivating effect (Hsiao, 2007) and the development of cognitive abilities to solve problems, creativity and critical thinking (Balasubramanian, Wilson, & Cios, 2006). These advantages can even benefit students with concentration problems (Cone et al., 2006). In addition, skills such as learning by discovery (Kirriemuir & Mcfarlane, 2004), motor and spatial coordination (Gros, 2007) and expert behavior (VanDeventer & White, 2002) are also developed while the player has fun. Games are the best way to lead the child to activity, self-expression, knowledge, and socialization (Falkembach, 2006). These benefits become even more accessible when the target audience is composed of children, since they are already familiar with technology and are Digital Natives (Prensky, 2001).

However, there is an obstacle to all educational Serious Games (SG): they are still little used because achieving a balance between quality and fun has been shown to be a difficult task (Savi & Ulbricht, 2008). Also, there are few studies that deal with the adequacy of SG design for children and those who did, reported only a few useful characteristics of the design (as will be shown by the related works).

The objective of this paper is to present a set of guidelines to help design SG for children and the validation process used to assess their relevance by experts. To do this, the work gives a theoretical foundation and related work before presenting the set of guidelines and then the validation process and discussions about it are presented.

2. Theoretical foundation

A Serious Game (SG) is a game designed for a primary purpose other than pure entertainment (Salen & Zimmerman, 2004). In a formal definition, it is a mental contest, played with a computer according to specific rules, which uses entertainment for the purpose of government or business training, education health, public policy, and strategic communication objectives (Zyda, 2005).

Child–Computer Interaction (CCI) is an area of scientific investigation that is concerned with the phenomena surrounding the interaction between children and computational and communication technologies (Read & Markopoulos, 2013). CCI encompass the study of the design, evaluation, and implementation of interactive computer systems for children, and the wider impact of technology on children and society (Hourcade, 2008). CCI addresses

the study of children's activities, behaviors, concerns, and abilities, as they interact with computer technology (Read & Bekker, 2011).

Guidelines are high-level statements ranging from a wide variety of cases to low-level declarations limited to specific contexts (Mariage, Vanderdonckt, & Pribeanu, 2005). Guidelines are recommendations to designers and developers when there are no specific standards. Guidelines are designed to certain processes according to what the best practices are. These are then practical questions that are intended to guide the decisions of the product development process. Guidelines serve as a way to achieve design principles, which are, in practical terms, tips on how a system should be at its final stage, reminders of aspects to be contemplated or how it should be developed (Herrington, Herrington, & Mantei, 2009). Guidelines also relate to design heuristics, with the difference that heuristics are essentially observed in practice (Nielsen, 2002).

The compilation of guidelines assists less experienced designers by showing a path to be followed, preventing them from pitfalls during the design (Leavitt & Shneiderman, 2006). Furthermore, the use of guidelines helps designers to reflect on their practices, evaluating whether they should be applied and/or refined to the work context. The goal of the guidelines is assisting researchers and designers who find themselves in similar contexts and problems (Herrington, Herrington, & Mantei, 2009).

3. Related work

According to Chiasson and Gutwin (2005), recommendation sets organized in an objective way to aid in the design of systems to children are scarce, often making designers adopt the same principles for traditional interfaces that are focused on adults.

Chiasson and Gutwin (2005) presents a catalog of design principles for technologies aimed at children's needs, abilities and expectations. The goal of this catalog is helping the designers in finding these design recommendations in an organized way and in one place. The catalog is organized into three categories: (i) cognitive, composed of literacy, feedback, mental development, and imagination; (ii) physical, which refer to motor skills and tangibility, and; (iii) social/emotional, which relate to engagement, social interactions, and collaboration.

The work of Nousiainen and Kankaanranta (2008) explored the experiences gained in three learning environment projects that involved the collaboration of elementary school children. The work discusses the expectations that this target audience has in relation to the interface of a software and its content. These expectations were categorized into four sets: (i) interface; (ii) appearance; (iii) theme, and; (iv) content.

Chorianopoulos et al. (2014) present three design principles for SG in Mathematics, which are: (i) involving the player with a hero story; (ii) employing familiar games mechanics and; (iii) provide constructive trial-and-error feedback to promote learning. In order to illustrate the application of these three principles, the authors developed a SG for teaching addition and subtraction with a focus on children of 13 and 14 years of age.

The work developed by (Falcão & Barbosa, 2015) aimed at presenting formative and objective analysis of relevant pedagogical aspects in the process of children's interaction with a game involving logic programming. According to the authors, these parameters present the potential to compose a method of evaluating games of this target group. The authors' perception, however, was that educational systems have their own characteristics, so that general heuristics do not always apply. In this way, based on the assumption that heuristics are considered an effective method of evaluating interfaces, the formative evaluation was analyzed in order to surpass Nielsen´s heuristics (Nielsen, 2002) to the context of educational software. The heuristics were approached from three groups: exploratory interaction; visual metaphors of the interface, and; interaction design.

These related works described only partial and limited initiatives to assist SG design for children and clearly show the need for a bigger and unified set of guidelines because some findings are complementary and others overlap. The set of guidelines we composed contains 40 guidelines and were divided into four categories, as will be explained next.

4. Methodology and guidelines proposal

The process to gather the guidelines was based on the aspects observed in the design, development, and evaluation of SG for children and their contribution to the CCI area. We conducted a literature search in November 2017 where ("Serious Games" AND "Children") and ("Game" AND "Guidelines" AND "Children") were used in Scholar Google and Academia.edu search engines. These engines are well-known for being large databases of open access scientific material. From the 15 papers initially found, we analyzed in each paper their set of guidelines, their related works and, their references. Subsequently, authors and works most commonly cited were also investigated, resulting in a final set of 29 sources, as it appears in Table 1.

Table 1. List of Guidelines, Their Group, Age Range and Source(s)

Group	Guideline	Age range	Source(s)
Input Guidelines	G1: Simplify the use of the mouse	4 – 7; 6 – 8; 9 – 13	Bruckman & Bandlow (2003); Stewart et al. (1998); Chiasson & Gutwin (2005); Druin et al. (2001); Hourcade (2008)
	G2: Avoid differentiating between left and right	2 – 5	Bruckman & Bandlow (2003); Strommen (1998)
	G3: Use efficient interaction mechanisms with interface elements	4 – 5; 4 – 7; 5 – 10;	Chiasson & Gutwin (2005), Druin et al. (2001); Tse et al. (2011); Hourcade (2008); Steiner & Moher (1992)
	G4: Allow spoken instructions	6 – 10	Vasconcelos et al. (2017); Lopes (2015)
	G5: Hide features of advanced levels	Not informed	Bruckman & Bandlow (2003); Halgren, Fernandes, & Thomas (1995)
	G6: Explore cooperative use	4 – 11	Inkpen (1997)
Output/ Interface Guidelines	G7: Easy-to-read font type usage	6 – 10	Bruckman & Bandlow (2003); Bernard et al. (2001); Vasconcelos et al. (2017); Nousiainen & Kankaanranta (2008)
	G8: Relate interface metaphor to children world	4 – 7; 6 – 9; 5 – 10	Bruckman & Bandlow (2003); Jones (1993); Halgren, Fernandes & Thomas (1995); Schneider (1996); Falcão & Barbosa (2015); Chiasson & Gutwin (2005); Druin et al. (2001); Nousiainen & Kankaanranta (2008)
	G9: Make interaction elements ease to spot	3 – 12	Bruckman & Bandlow (2003); Gilitz (2002); Carvalho, Gasparini, & Hounsell (2015)
	D10: Use appropriate interaction time to children's age	Not informed	Tse et al. (2011); Carvalho, Gasparini, & Hounsell (2015)
	G11: Use meaningful icon as a replacement or help to texts	4 – 7	Chiasson & Gutwin (2005); Tse et al. (2011); Hanna et al. (1998)
	G12: Prefer recognizing than remembering	2 – 6; 6 – 9	Falcão & Barbosa (2015); Nasiri, Shirmohammadi, & Rashed (2017)
	G13: Use of visual interface mainly	6 – 10	Chiasson & Gutwin (2005); Druin et al. (2001); Carvalho, Gasparini, & Hounsell (2015); Vasconcelos et al. (2017)
	G14: Provide accurate and fast feedback	4 – 7; 6 – 9; 9 – 14	Falcão & Barbosa (2015); Chiasson & Gutwin (2005); Steiner & Moher (1992); Said (2004)
	G15: Show clearly the status of the system	7 – 12; 11 – 12	Chiasson & Gutwin (2005); Hanna et al. (1998); Nousiainen & Kankaanranta (2008)
	G16: Prefer to use characters for interaction	12 – 14	Chiasson & Gutwin (2005); Hanna et al. (1998); Lester et al. (1997)
	G17: Present information to users according to their level of development	Not informed	Hourcade (2008)
	G18: Use interfaces and conventions that are known by the users	6 – 8; 11 – 12	Nousiainen & Kankaanranta (2008); Rosas et al. (2003)
	G19: Layout must be rich in	7 – 12	Nousiainen & Kankaanranta (2008)

	content with little empty spaces		
	G20: Present scoring and/or classification as clear as possible in screen	7 – 12; 6 – 17	Nousiainen & Kankaanranta (2008); Pausch, Vogtle, & Conway (1992)
	G21: Interface must look and behave as real as possible	6 – 9	Falcão & Barbosa (2015); Nousiainen & Kankaanranta (2008)
	G22: A great variety of themes/skins must be available	7 – 12	Nousiainen & Kankaanranta (2008)
	G23: Information must be presented in more than one way	6	Lopes (2015)
	G24: Reward the player	6 – 17	Chiasson & Gutwin (2005); Hanna et al. (1998); Pausch, Vogtle, & Conway
	G25: Devise a way to emphasize clickable interface elements	Not informed	Chiasson & Gutwin (2005); Hanna et al. (1998)
Content Guidelines	G26: Documentation and Help must be objective and easy to find	6 – 9	Falcão & Barbosa (2015); Xie, Antle, & Motamedi (2008)
	G27: Allow players to undo and correct mistakes	13 – 14	Chorianopoulos, Giannakos, & Chrisochoides (2014)
	G28: Allow user to explore the system and build things	7 – 12	Nousiainen & Kankaanranta (2008)
	G29: Logically scaffold the content	4 – 6	Pereira & Peruzza (2002); Carvalho, Gasparini, & Hounsell (2015)
	G30: Fit vocabulary to target audience	4 – 6	Pereira & Peruzza (2002)
	G31: Fit the game to the user´s level of experience	12 – 14	Chiasson & Gutwin (2005); Hanna et al. (1998); Lester et al. (1997)
	G32: Design interesting and challenging activities	6 – 10	Chiasson & Gutwin (2005); Hanna et al. (1998); Vasconcelos et al. (2017)
	G33: Teachers must be able to configure the game accordingly if the game is to be assisted by them	4 – 6	Pereira & Peruzza (2002); Carvalho, Gasparini, & Hounsell (2015)
	G34: Make the target content fit in naturally with its surrounding context	6 – 8	Rosas et al. (2003)
	G35: Use narratives/stories to engage players	13 – 14	Chorianopoulos, Giannakos, & Chrisochoides (2014); Voytilla & Vogler (1999)
	G36: Clearly define goals	4 – 6; 13 – 14	Chorianopoulos, Giannakos, & Chrisochoides (2014); Pereira & Peruzza (2002); Hanna et al. (1998)
	G37: Avoid cognitive loads	2 - 6	Nasiri, Shirmohammadi, & Rashed (2017)
Control Guidelines	G38: Allow many different levels of the game	4 – 6	Pereira & Peruzza (2002); Carvalho, Gasparini, & Hounsell (2015)
	G39: Show players' tracks (already visited places and contents)	2 – 5; 5 – 10	Strommen (1998); Chiasson & Gutwin (2005)
	G40: Teachers must be able to control the game	Not informed	Hourcade (2008)

When the age range or infancy stage is not informed in Table 1, it should be understood that the source from which the guideline was taken did not explicitly make this information available, and in this way, it was considered that the recommendation is not restricted to a specific period of childhood. Table 1 shows that the age range varies from 2 to 17 years of age and each paper dealt with a different span within this range.

We found some conflicts regarding to the amount of content that should be presented to children in the computer/game screen: some suggested it should be dense and others, to be as simple as possible. When conflicting guidelines appeared, it was looked at the number of papers that backed them up: those guidelines with more related papers were included in our list. The whole set of guidelines is presented in Table 2, each one is presented as a sentence followed by an explanation.

Table 2. The whole set of guidelines and their explanation

Guidelines	Explanation
G1: Simplify the use of the mouse	While targeting standard user interfaces, one should notice that the motor development of children is not the same as in adulthood. Children are growing and may have difficulty using devices designed for adults, such as the mouse (Chiasson & Gutwin, 2005). This difficulty appears either in more complex actions such as holding down the drag button or simpler actions such as double-clicking. It can also be hard for children to memorize the actions of each mouse button.
G2: Avoid differentiating between left and right	As well as motor development, cognitive aspects are also evolving during childhood. For this reason, children may often not understand or have trouble with left and right concepts (laterality), either of themselves or by taking other objects as reference (Strommen, 1998). An example of a product that takes care of it in its design is "Hug & Learn Baby Tad" (http://www.leapfrog.com, accessed in July 2018). In this game, different actions are assigned when each paw is pressed (the child's avatar is a dog and therefore, his/her hand becomes a paw) to accommodate children who do not know how to differentiate their paws as left and right. Thus, each paw gets a different mark, so the child understands that each avatar's paw generates a specific action.
G3: Use efficient interaction mechanisms with interface elements	Underdeveloped manual dexterity does not allow some children to easily perform drag and drop, for example (Chiasson & Gutwin, 2005). Besides that, very small interaction elements may require accuracy that children do not have. Because of that, interaction mechanisms should consider the child's manual skills as the elements should have larger sizes and spacing.
G4: Allow spoken instructions	As said by Vasconcelos et al. (2017) and Lopes (2015), in cases where the user is in the process of literacy, audio instructions provided by the system can be helpful. But even with the spoken instruction option, it is suggested to keep the text so that the child can follow the heard instruction by reading.
G5: Hide features of advanced levels	As noted by Halgren, Fernandes and Thomas (1995), children's tendency to interact with objects on the screen makes offering many possibilities a kind of trap to new users. Thus, one solution is to keep the most complex features "hidden" in menus or shortcuts, to continue allowing their use by advanced users and not confusing beginners.
G6: Explore cooperative use	Children accept shared devices use better than adults (Inkpen, 1997) and productivity and satisfaction gains can be generated through cooperation between children during games.
G7: Easy-to-read font type usage	Small or customized fonts present a greater challenge than reading itself because the reading ability is under development. The study by Bernard et al. (2001) pointed out that children between 9 and 11 years old prefer font size 14 over the generally used font size 12. According to Bruckman, Bandlow and Forte (2002), many designers empirically apply the rule that "the younger the child, the larger the font size." Finally, uppercased letters should be preferred because it is with this type of font that children are literate (Vasconcelos et al., 2017).
G8: Relate interface metaphor to children world	The use of metaphors or analogies must be carefully planned even for youngsters. Particularly for children, they are often not able to understand metaphors that work for adults, for example, those related to the office (Jones, 1993).
G9: Make interaction elements ease to spot	Unlike adults who tend to scan the screen with their eyes, read some important points of information and then decide to interact with the system; children rarely scroll to look for information and their first actions are not to look at the interface but to interact with animated elements displayed on the home screen (Gilitz, 2002).
G10: Use interaction time according to children's age	As for cognitive effort, a longer interaction time required by children must also be considered. This is particularly relevant in the case of games, as the time to perform the proposed activity is after part of the game's challenge (level design) (Carvalho, Gasparini, & Hounsell, 2015).

G11: Use meaningful icon as a replacement or help to texts	Icons should be used to give meaning to actions and / or texts because, depending on age, the user is in the process of literacy or has not yet reached this stage (Chiasson & Gutwin, 2005).
G12: Prefer recognizing than remembering	This guideline is not specific to children, but it applies to them. As said by Falcão & Barbosa (2015), the information should be clear enough that the user, when faced with the same element, can recognize its use instead of having to memorize it.
G13: Use of visual interface mainly	This guideline is especially important for non-literate users. When the user is in the process of literacy, it may be interesting to merge visual and textual elements (Vasconcelos et al., 2017). But even for literate users, very textual interfaces can quickly become tiresome.
G14: Provide accurate and fast feedback	Children are impatient users and want quick feedback from the system. If not, they can repeat the action until a system response is given (Chiasson & Gutwin, 2005). In addition, when feedback is too late, the child may perceive it as a random response rather than perceiving it as an actual feedback.
G15: Clearly show the status of the system	If the system takes time to process, the user must be clearly informed of what is happening. Especially in the case of games, if the system is waiting for player input for a long period of time, some feedback should be given to the user to perform some action. Toe-tapping is an example of this type of feedback, indicating that the system is "waiting" for action (Hanna et al., 1998).
G16: Prefer to use characters for interaction	Characters are virtual creatures used to communicate with the user. Even characters who do not interact nor give advice are positively received by children. Their use, however, should not be intrusive and should not be too long lasting, causing the player to lose focus (Hanna et al., 1998).
G17: Present information to users according to their level of development	Depending on age and intellectual development, different forms of content presentation and / or goals (in the case of games) may be desired (Hourcade, 2008). In general, the more experienced the greater the optimization regarding the presentation of information that the user wants.
G18: Use interfaces and conventions that are already known by the users	Nousiainen and Kankaanranta (2008) have shown that children expect new systems to have similar behaviors and patterns to the software they already know. In SG, inspiration can be sought from commercial ones.
G19: Layout must be rich in content with little empty spaces	Nousiainen and Kankaanranta (2008) also noted that by participating in the design process, children designed rich content interfaces with few empty spaces and they were comfortable about it.
G20: Present scoring and/or classification as clear as possible in screen	Nousiainen and Kankaanranta (2008) observed that children between 7 and 9 years old, when designing interfaces, wanted ranking and score information to be always visible on the screen.
G21: Interface must look and behave as real as possible	In addition to the fact that children from 7 to 9 years old prefer interfaces having a realistic look (Nousiainen; Kankaanranta, 2008), Falcão and Barbosa (2015) suggest that interface metaphors do not use complex abstractions in order to exceed the user's comprehension capabilities.
G22: A great variety of themes/skins must be available	Another children's wish observed by Nousiainen and Kankaanranta (2008) is that the software should have different themes and that each user could choose aspects such as objects and colors according to their preference.
G23: Information must be presented in more than one way	In the game developed by (Lopes, 2015), the numbers are represented by a digit, text, figure, all expressing the amount, character gestures and audio instructions. All of these ways of representation aim to convey the same information so that the expressed quantity is assimilated.
G24: Reward the player	Reward structures should consider the level of child development and the context of use. They are used to keep the player engaged in the goals and motivated to continue performing the tasks (Hanna et al., 1998). This fact was observed by Pausch, Vogtle and Conway (1992) in children from 6 to 17 years old who, in the absence of scores in the game, started to count them on their own.
G25: Devise a way to	Hanna et al. (1998), suggest adding 3D effects to buttons to make them appear clickable

emphasize clickable interface elements	or playing audios when these clickable objects are pointed by the mouse. These ways of highlighting key elements allow the user to distinguish the most important objects, usually the ones they can interact with, from other objects in the interface.
G26: Documentation and help must be objective and easy to find	Ideally, software should be intuitive enough for the user to interact without the need for documented help but if existent, it should be well loaded and briefly addressed because children do not yet have strong text interpretation skills (Falcão & Barbosa, 2015).
G27: Allow players to undo and correct mistakes	In the game developed by Chorianopoulos, Giannakos and Chrisochoides (2014), besides observing in real time whether the action performed was correct or wrong, the player was able to correct it with another input that complemented the previous one. This feedback and dynamics model not only reports the error but allows the player to instantly correct it.
G28: Allow user to explore the system and build things	This principle was observed in participatory design experience with elementary school children as one of the requirements they expected in an ideal system. According to (Nousiainen; Kankaanranta, 2008), they would like to be able to create features, characters and choose where the game goes.
G29: Logically scaffold the content	As noted by Pereira and Peruzza (2002) being one of the requirements of developed SG, the main goal of SG, i.e., its content, should be approached gradually. Unleashed content can make the game massive or overly complex, discouraging the player in both cases.
G30: Fit vocabulary to target audience	Vocabulary care should be taken not only so that the textual information is understood by the user but also so that it does not become cumbersome (Pereira & Peruzza, 2002).
G31: Fit the game to user's level of experience	Activities within the system must be shaped as the child evolves as a user, that is, as a child dominates the actions, the system must allow him to optimize them, reaching other levels within the system (Chiasson & Gutwin, 2005).
G32: Design interesting and challenging activities	Thoughtful activities help, we seek to maintain the child's attention and motivation to continue using the software. In the case of games, this goal can be achieved through the appropriate level design or the possibility of different activities within the game (Chiasson & Gutwin, 2005; Vasconcelos et al., 2017).
G33: Teachers must be able to configure the game accordingly if the game is to be assisted by them	The teacher should be able to include, exclude and change the content in order to control the software and thus, adjust it to child's needs and teaching purposes (Carvalho, Gasparini, & Hounsell, 2015).
G34: Make the target content fit in naturally with its surrounding context	The idea is that the child would assimilate the target content while having fun playing in a natural way, without worrying about educational aspects (Rosas et al., 2003).
G35: Use narratives/stories to engage players	In the game developed by Chorianopoulos, Giannakos and Chrisochoides (2014), for example, there is the hero narrative proposed by Vogler (1998), which is based on presenting to the player a hero who faces a problem to be solved by him. From the moment the player commits to the adventure, there is a motivation for a general goal to meet the challenges along the way.
G36: Clearly define goals	As done by Chorianopoulos, Giannakos, and Chrisochoides (2014), the idea is that the challenges proposed by the game are brief enough to be understood by the player.
G37: Avoid cognitive loads	According to Nasiri, Shirmohammadi and Rashed (2017), children are easily distracted and quickly feel tired of performing monotonous tasks. Therefore, besides making the activities interesting, they should not last long.
G38: Allow many different levels of the game	Pereira and Peruzza (2002) observed the possibility that different levels of the game are accessed which allows specific content to be addressed individually and the difficulty level of the game to be manually adjusted to the player.
G39: Show players' tracks (already visited places and contents)	Children hardly remember the areas already explored by them (Strommen, 1998). Thus, to prevent the user from navigating in circles, some way of representing that certain content that has already been visited should be used. Furthermore, the actions taken by the player can serve as a tool for analysis and performance evaluation and its evolution by the teacher.

G40: Teachers must be able to control the game	In the case of games that have their use accompanied by a teacher, the teacher must have control over interventions such as pauses for corrections or explanations of the content (Hourcade, 2008).

5. Validation

In order to validate the guidelines, we sent an electronic questionnaire in Portuguese to 868 experts by email from which 59 subjects answered. Experts' emails were gathered from authors that published full or short papers related to children in the SBGames (Brazilian Symposium on Games and Digital Entertainment) from 2016 to 2018 and in SBIE (Brazilian Symposium on Informatics in Education) in 2018.

We asked experts if they considered each guideline to be (i) appropriate (a YES/NO question if they agree with such guideline), (ii) clear, and (iii) important regarding designing games for children. The first question yielded an index from 0 to 10 considering the number of positive responses divided by the total number of answers (n = 59). The last two questions were answered by choosing a value between 0-none to 10-a lot. Each guideline was presented as a "key phrase" (as listed in Table 1) and a descriptive paragraph underneath (as listed in the previous section).

According to Sharp, Preece and Rogers (2019), "if the questionnaire is long, the questions may be subdivided into related topics to make it easier and more logical to complete" (p. 129). Therefore, in order to facilitate experts to analyze all forty guidelines, we divided these into four groups, similar to those groups used by Nousiainen and Kankaanranta (2008). The guidelines were grouped into: Input (G1 to G6); Output/Interface (G7 to G25); Content (G26 to G37), and; Control (G38 to G40). We kept the grouping for latter reference because such division also allows designers to focus on elements to better suit children's expectations. Table 1 presents all guidelines followed by their sources, from which they were obtained directly or by interpretation. Therefore, at the end of each group of guidelines, we asked open questions if experts found guidelines to be conflicting between each other; repeated, or; overlapping and, at the very end of the questionnaire we asked for "doubts, complaints and/or suggestions." The response time observed was 25 minutes on average (SD = ± 11).

Experts that answered were 54.2% male and 45.8% female, and they had 30.5% PhD; 39.0% master and; 20.3% graduate degrees. They were of 34,7 years of age on average (SD = ± 10.38) and with 10,78 years of experience on game/children related issues on average (SD = ± 8.26). Most of them work on software-related (37.3%), education-related (35.6%) and game-design (15.2%) research/development. One can see that scores vary along the whole list despite its length which suggests that experts did not lose their criticism along the way.

To obtain an overall understanding of each guideline a "Relevance score" was calculated as the average between clearness, agreement and importance scores. "Relevance" gives a better evaluation of each guideline's usefulness because it is not enough to have one that is clear but unimportant or, agreed but unclearly stated. Table 3 presents the set of guidelines and their agreement, clearness, importance and relevance scores. For a further description and a more detailed explanation of the guidelines, see (Valenza, 2018) and (Valenza, Hounsell, & Gasparini, 2019). All the scores are shown in Table 3 with their mean (μ) and standard deviation (SD) values.

Only two guidelines (G19 and G21) scored Relevance below 7,0, both from the output/interface group and therefore they are somehow related. Their scores were affected by the agreement score which was very low score: Guideline G19 might have scored low because it is a heuristic from the field of Human-Computer Interaction and, somehow might conflict with the attempt to reduce cognitive loads, expressed by G37. Guideline G21, besides being not trivial regarding SG design for children, it might conflict with common sense that interfaces for children should be colorful and iconic.

Regarding open questions, 14 experts answered on the "doubts, complaints and/or suggestions" field; 23 answered "conflicting guidelines"; 1 answered "repeated guidelines," and; 4 answered "overlapping guidelines." Most of the experts used the space to congratulate on the work or to ask details on specific guidelines (that can be found in their source reference). Actual suggestions include: ranking the guidelines by relevance; develop a checklist; better specify children's age; to shrink the list by focusing only on what is related exclusively to SGs; to better specify if guidelines apply to children with special needs, and; the length and time spent on the questionnaire.

Table 3. List of guidelines and their agreement, clearness, importance and relevance

Guideline	Agree	Clear		Important		Relevance
		μ	*SD*	μ	*SD*	
*G*1: Simplify the use of the mouse	8.64	8.64	1.66	8.63	2.18	8.64
*G*2: Avoid differentiating between left and right	8.47	8.42	1.55	8.53	2.19	8.47
*G*3: Use efficient interaction mechanisms with interface elements	10.00	8.78	1.57	9.32	2.21	9.37
*G*4: Allow spoken instructions	9.32	9.41	1.57	9.17	2.22	9.30
*G*5: Hide features of advanced levels	9.15	9.15	1.58	8.93	2.23	9.08
*G*6: Explore cooperative use	8.47	7.98	1.59	8.07	2.25	8.18
*G*7: Use font type that ease reading	9.32	9.39	1.60	9.46	2.27	9.39
*G*8: Relate interface metaphor to children world	8.98	7.88	1.61	8.58	2.28	8.48
*G*9: Make interaction elements ease to spot	9.32	9.17	1.62	9.34	2.30	9.28
*D*10: Use appropriate interaction time to children's age	9.66	8.90	1.63	9.12	2.32	9.23
*G*11: Use meaningful icon as a replacement or help to texts	10.00	9.47	1.65	9.59	2.34	9.69
*G*12: Prefer recognizing than remembering	9.83	8.10	1.67	9.17	2.35	9.03
*G*13: Use visual interface mainly	9.49	9.25	1.68	9.44	2.36	9.40
*G*14: Provide accurate and fast feedback	9.83	9.41	1.69	9.58	2.38	9.60
*G*15: Show clearly the status of the system	10.00	9.22	1.55	9.41	2.31	9.54
*G*16: Prefer to use characters for interaction	9.15	8.76	1.56	8.53	2.33	8.81
*G*17: Present information to users according to their level of development	9.66	8.73	1.56	9.20	2.34	9.20
*G*18: Use interfaces and conventions that are known by the users	9.49	9.25	1.58	9.17	2.37	9.31
*G*19: Layout must be rich in content with little empty spaces	5.59	8.31	1.59	7.03	2.39	6.98
*G*20: Present scoring and/or classification as clear as possible in screen	9.49	9.14	1.49	9.20	2.41	9.28
*G*21: Interface must look and behave as real as possible	4.07	8.42	1.51	6.59	2.42	6.36
*G*22: A great variety of themes/skins must be available	8.31	9.02	1.52	7.98	2.44	8.44
*G*23: Information must be presented in more than one way	8.98	8.34	1.32	8.41	2.46	8.58
*G*24: Reward the player	10.00	9.29	1.33	9.66	2.50	9.65
*G*25: Devise a way to emphasize clickable interface elements	9.32	9.10	1.31	9.14	2.53	9.19
*G*26: Documentation and Help must be objective and easy to find	8.81	9.19	1.32	8.19	2.55	8.73
*G*27: Allow players to undo and correct mistakes	9.49	9.39	1.33	9.19	2.57	9.36
*G*28: Allow user to explore the system and build things	9.15	9.10	1.34	8.61	2.61	8.95
*G*29: Logically scaffold the content	9.49	8.71	1.35	9.31	2.65	9.17
*G*30: Fit vocabulary to target audience	10.00	9.51	1.36	9.71	2.33	9.74
*G*31: Fit the game to user's level of experience	9.49	9.17	1.36	9.54	2.35	9.40
*G*32: Design interesting and challenging activities	10.00	9.17	1.39	9.58	2.30	9.58
*G*33: Teachers must be able to configure the game accordingly if the game is to be assisted by them	9.49	9.17	1.40	8.68	2.34	9.11
*G*34: Make the target content fit in naturally with its surrounding context	8.31	8.36	1.42	8.75	1.97	8.47
*G*34: Make the target content fit in naturally with its surrounding context	8. 31	8.36	1.42	8.75	1.97	8.47
*G*35: Use narratives/stories to engage players	9.83	9.08	1.45	8.80	1.40	9.24
*G*36: Clearly define goals	9.49	9.54	1.08	9.49	1.41	9.51
*G*37: Avoid too much cognitive loads	8.98	9.47	1.08	9.03	1.44	9.16
*G*38: Allow many different levels of the game	8.81	8.24	1.09	8.15	1.14	8.40
*G*39: Show players' tracks (already visited places and contents)	9.15	8.90	1.09	8.95	1.12	9.00
*G*40: Teachers must be able to control the game	8.98	9.36	1.09	8.58	1.14	8.97

To answer these comments, we stress that we only reported what was found and, many of the sources did not specify some details but we could see that all the papers were surely dealing with children and SGs. By the time we did the validation, we did not present the age range as part of the information to experts, Table 1 in this text include such

information. We agree that some guidelines might be applied to a specific age span or specific group (autistic children) but we reckon that all of them should be considered while designing a SG regardless because, the broader the analysis, the better the design.

6. Discussion

Considering that exposing children to technology and to games in particular is becoming ever so usual, it is important that these artifacts must be designed accordingly to its target audience taking into account users' skills, interests and needs (Hourcade, 2008). These careful design and development are essential to produce serious games (SG) of higher standards of quality. Investigating which design decision produces a better solution is valuable to compose a set of design guidelines specially targeted to this population. However, doing so seems to be rare and we could find just a few organized and tested guidelines (most of them, lessons learned from projects of a different goal). It is usual, therefore, that designers were taken general principles for traditional interfaces that are aimed for adults (Chiasson & Gutwin, 2005) but this is far from a good approach for children.

Although it is not a new topic and it is an important issue, it was quite difficult to find research papers in the literature with guidelines proposals for designing games for children. That is why we looked up papers that were presenting tips for designing SG for children as a starting point. Their approach was studied and compared to others to see how children's needs were complied to.

Children population can be sub-divided into many sub-groups such as children that can (already) read, children with special needs (autism, Down syndrome etc.) and, children of different ages. We see that these differences would yield different guidelines (some would be rendered inappropriate and some new ones could arise). However, authors did not detail such issues and then, we included all of them, regardless.

It is possible to observe from Table 1 that reference (Chiasson & Gutwin, 2005) contributed with 10 guidelines; (Hanna et al., 1998) with 9; (Nousiainen & Kankaanranta, 2008) with 8; (Bruckman & Bandlow, 2003) with 7; (Pereira & Peruzza, 2002) with 5; and all the remaining references contributed with less than 5 guidelines. Ten references contributed with 2 guidelines and eight references contributed with only one guideline.

Most of the guidelines (26) scored Relevance above 9,0 and 22 scored above 8,0. Even the lowest scores were above the middle of the scale which suggests that experts found the set of guidelines to be worth of attention while designing a SG for children.

We argue that complying to all of the given guidelines would render a much more satisfying serious game for children. However, achieving such compliance might come to a higher cost in terms of time and/or money. Thus, we suggest designers to browse through all guidelines but prioritize compliance to those that present a reasonable cost-benefit ratio and higher relevance (see Table 3). Nevertheless, it is better to have such a long list and designers decide to skip some rather than omitting any that could render the game less suitable to children. Thus, the designer would have to prioritize some issues against others. Grouping the guidelines was also aimed at facilitating such analysis. Also, we suggest designers to go deeper into by referring to guidelines' sources to fully understand them and to better grasp their reach (see Table 1).

7. Conclusion

This paper presented a set of guidelines gathered from the scientific literature of projects specially targeting serious game design for children. Guidelines presented here, although gathered from the literature, still need further research to better specify the scope of application for children (regarding sex, game genre, and special needs, for instance). We urge the community to further research on the topic by probing some of the guidelines and thoroughly investigate them to different groups of children and to make the research scope clearer.

The set of guidelines was not meant to be complete neither final. As long as technology and children's interaction with it changes the guidelines will also change. Nevertheless, we argue that children's perspectives must be considered as much as possible while designing SG. If not by direct involvement in the designing process (as in a

Participatory Design approach, for instance), at least by considering relevant guidelines such as the ones we compiled here. Future work includes expanding the validation to non-Portuguese speakers and building an instrument that would facilitate including, excluding and updating the guidelines by SG designers and researchers.

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