

Conceptual Framework to Support a Web Authoring Tool of Educational Games for Deaf Children

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Abstract: The Deaf people constitute minority communities that, for many years, suffered with the lack of tools for teaching and learning materials based on Sign Language - the natural language that define their social identity and culture. The Education Informatics presents great potential in development of tools for teaching support, but have not produced effective tools for Deaf people, especially to support the learning process of Deaf children. Educational Games have shown successful experiences when used in the learning process of different knowledge fields and the results tend to be more relevant when such games are used with children and teenagers. However, the development of an educational game requires several skills related to software engineering, programming, design, illustration, pedagogy, among others. This paper presents a framework for design of effective educational games for Deaf children based on Children Teaching Methodology and Educational Digital Games literature. The results include: the application of the framework in creating a web authoring tool that allows non-experts in game design, such as Deaf children teachers, to create educational games in a simple and semi-automatic way; and an example game generated by the tool.

1 INTRODUCTION

Data from the most recent National Health Survey (PNS) of the Brazilian Institute of Geography and Statistics (IBGE) in 2018 show that 6.7% of the Brazilian population have some type of disability (IBGE, 2018). According to the latest survey, 1.1% of the Brazilian population has a hearing impairment. About 0.9% of Brazilians were deaf due to some situation during life and 0.2% were born deaf. Therefore, there are over four hundred thousand Brazilians who were born deaf.

Within this universe, there is a complicating factor: international researches show that more than 90% of children born deaf are from hearing families (Mitchell and Karchmer, 2004) (Eleweke and Rodda, 2000). This means that these children end up not having an effective means of communicating with their parents, resulting in them not developing their natural form of communication (Sign Language) at home and in the early stages of childhood. This fact occurs because of the lack of Sign Language knowledge by most parents, as well as society in general.

Important theorists in the field of Education emphasize the importance of language acquisition for the cognitive development of the child (Piaget, 1923) (Vygotsky, 1964) and for acquisition of language by Deaf Brazilian children (Karnopp, 1994) (Quadros, 1997). Thus, it is fundamental for the personal development of the Deaf¹ child that he or she is taken to places where he can learn and practice his country's Sign Language learning such as day care center and special school.

Taking into account, first, the needs of the Deaf communities for technologies that assist their education processes, as well as the potential for the application of digital games in education, a niche of research is perceived. On the other hand, the development of digital games requires advanced knowledge of programming, graphic libraries and manipulation of user inputs. This hinders and, in general, prevents educational games from being built by those people who work directly with the Deaf and hold the knowledge

¹This convention is used to refer to Deaf communities as linguistic minorities, not as disabled people (Felipe, 1989).

of what needs to be taught - the teachers.

In this sense, the guiding questions raised for this research paper are:

1. How can game designers or professional game developers build suitable educational games for Deaf children?
2. Is it possible that teachers of Early Childhood Education without advanced computer skills can create digital educational games for their Deaf students?

Therefore, this paper presents a conceptual framework for design of effective educational games for Deaf children based on Children Teaching Methodologies and Educational Digital Games literature. The results includes the application of the framework in the development of an authoring tool allowing non-experts in game design, such as Deaf children teachers, to create educational games in a simple and semi-automatic way. For the test and validation phase, the paper presents the generation of a game from the point-and-click adventure genre for Deaf children through the use of the developed tool.

The remainder of this paper is structured as follows: Section II discusses the basic concepts that substantiate this work, such as Educational Video games and Guidelines for Early Childhood Education. Section III presents the core making of this work, the proposed conceptual framework for educational game design. Section IV shows the description and features of the resulting web authoring tool for educational games. Finally, Section V ends the paper with the final considerations about the research.

2 THEORETICAL BASES

The use of computers in education began in 1967 with Seymour Papert, the best known theorist, creator of the Logo programming language and one of the pioneers of artificial intelligence (Papert et al., 1980) (Balacheff, 2017). In Brazil, the use of computers in education started with Valente at State University of Campinas - UNICAMP in 1991, through the EDUCOM Project in Special Education, implemented in five centers: UNICAMP, Federal University of Pernambuco - UFPE, Federal University of Minas Gerais - UFMG, Federal University of Rio de Janeiro - UFRJ and Federal University of Rio Grande do Sul - UFRGS (Feliipe, 1991). The EDUCOM Project implemented at UFPE worked with the language Logo, using a bilingual proposal: Libras (Brazilian Sign Language) and Portuguese for communication with Deaf participants. Since then,

the projects using computer for education have been emerging and are increasingly consolidating as pedagogical proposes for education.

2.1 Educational Games

Currently many electronic games, digital games, computer games or video games have been used for different proposals. All of these terms are used to identify computer programs designed to entertain and amuse the user, while he interacts with it.

The ability of video games to engage and challenge players through ever more complex and demanding stages and the range of cognitive, linguistic and sociocultural practices generated by games have led to increased interest in the use and study of digital games in schools (Beavis et al., 2015). Video games are no longer considered mere amusements of children and have come to be seen as a significant medium of contemporary communication and expression.

Educational games are those designed to teach while distracting. Many scholars in the areas of Education, Cognition, and Psychology have been working tirelessly on educational games over the years (Annetta, 2010). Such games are developed specifically for pedagogical purposes, usually with children as a target audience, and topics such as Geography, Math, Reading, among others, being taught while playing. Examples include Oregon Trail (by Sierra On-Line), one of the first educational games ever, created to teach History; Reader Rabbit (by The Learning Company), a game for teaching Reading and Spelling; and Math Blaster (by Davidson Associates), focused on the teaching of Arithmetic (Novak, 2011).

The Educational Game design still consists of a difficult operation, which requires a well-formed relation between instructional process and game design to be effective (Hotte et al., 2017). The literature presents good examples of game design applied to educational and learning games. Nevertheless, the development and the design are complex activities (Hotte et al., 2017), not allowing holders of knowledge and specialists in teaching methodologies, such as educators, to produce an educational game in a simple way.

The process to develop an educational game involves the collaboration of several profiles, such as teachers, software developers, game designers, illustrators, pedagogical specialists, among others (Hotte et al., 2017). This process is complex and makes it difficult for a person who is unfamiliar with game design to develop an effective educational game. Therefore, this research aims to build a framework to guide

the design of educational games for Deaf children and presents a web authoring tool that allows non-specialists to build games in a simple and semi-automatic way.

Educational Games can provide an immersive environment that enables more contextual education using elements such as interactive scenarios, challenge mechanisms, artifacts and people interactions (i.e. collaboration), and are able to simulate real-world situations (Guigon et al., 2018).

Adaptation is a key concern for the development of Educational Games, particularly for people with special needs (Laforcade et al., 2018). Therefore, it is important to have a way to allow teachers and pedagogues (people with no-experience in game design) to build a game semi-automatically by adapting elements such as: learning scenarios, dynamics and elements of the domain, to meet unique characteristics of the students, like the Deaf children.

2.2 Early Childhood Education

The Early Childhood Education is the stage of Education that aims at the Integral and Integrated Development of the Child. That is, it involves the psychological, sociolinguistic, physical, motor and psychomotor development. Teaching Methodologies must take into account different aspects of the target audience to be taught, such as age, social situation and special needs. This is extremely relevant in Early Childhood Education, in which small differences in the age of the students tend to lead to a completely different world understanding and abilities.

The educational foundations of this work are the most recent National Guidelines for Early Childhood Education (Brasil, 2009) and the latest National Common Curricular Base (Brasil, 2017). Both of them are normative documents, written by the Ministry of Education (MEC) in partnership with the National Council of Secretaries of Education (CONSED) of the Brazilian government.

Two guiding axes of pedagogical practices form the The National Curriculum Guidelines for Early Childhood Education: **Interaction** and **Play**, as shown in Figure 1.

Both constitutional axes have the potential to be harnessed in educational computer games. Interaction: Children who play the same game tend to chat and socialize about the things they experience during their interaction with the game. Play: The act of playing a game, by itself, can be understood as play, and therefore bring all the benefits of the game as a stimulus to creativity, overcoming obstacles, self-knowledge and concentration.



Figure 1: Pedagogical Practices in Early Childhood Education (Brasil, 2009).

Some fundamental bases constitute the National Curriculum Guidelines for Early Childhood Education and the National Common Curricular Base. These bases are the Rights of Learning and the Fields of Experiences.

The Rights of Learning presented by these documents can be understood as the capacities and competences that the children need to develop in this stage of Education. There are six Rights of Learning in the Early Childhood Education: Live together; Play; Participate; Explore; Express; Know yourself. All of them can be explored and integrated with game mechanics

The Fields of Experience are divided in five groups, and they are responsible to form the curricular organization of this stage of education. The Fields of Experience are:

- The self, the other and the we;
- Body, gestures and movement;
- Traits, sounds, colors and shapes;
- Listening, speaking, thinking and imagination;
- Spaces, times, quantities, relationships, and transformations.

3 THE CONCEPTUAL FRAMEWORK

The Conceptual Framework (CFW) intends to provide support for the development of educational digital games for Deaf children. Its target user profile are programmers and game designers who wish to build and implement their own educational game.

The Framework's goal is to allow the construction of educational games projects for Deaf children, regardless of development technology, programming

language, game engines, graphical resolutions, destination platforms (consoles, computers, tablets, smartphones...), technical configurations, and operating systems.

With the use of the CFW, the developed educational games should have the necessary foundation in relation to the user interface and interaction environment, the mechanics of gameplay, the methodology of teaching and the educational content. Thus, the developer who creates his game supported by the framework will have, in his software product, the presence of features that the program needs to contain, while still being capable of developing a unique application.

The basic inputs supporting the construction of the conceptual framework come from the fundamentals of the main sub-areas with which this work is related: Electronic Games, Informatics in Education, Educational Games, Human-Computer Interaction and Deaf Children Education.

The modularization of the CFW is inspired by the general architecture of Intelligent Tutoring Systems (ITS), which is divided into Specialist Model, Student Model, Domain Model and the Interface (Nwana, 1990). Although the educational games that one wishes to construct are not tutoring systems, the proposed modularization is also adequate for this purpose, since the elements present and the aspects treated in the different ITS models are also largely present in the process of construction and subsequent use of educational games.

3.1 The Conceptual Framework Modules

The support structures of the proposed CFW are four: Gameplay and Tutoring, Teaching-Learning, Student or Player, and Graphics and Interface. Each module in the Conceptual Framework has a key-role in the production of an educational game for Deaf children. The modules have specific responsibilities regarding the game, but all modules interact with each other, since the features of a game, even with its peculiarities, are interconnected. Figure 2 displays the four modules and their interconnections.

The **Gameplay and Tutoring Module** is responsible for offering the mechanics of digital games and for interrelating them with what one wishes to teach. In turn, the **Teaching-Learning Module** is the one that encompasses the concepts and educational contents to be constructed, the order and the way in which they will be presented. The **Student or Player Module** has the role of verifying the player's performance during the time they are executing the game tasks, adapting the difficulty, providing feedback regarding

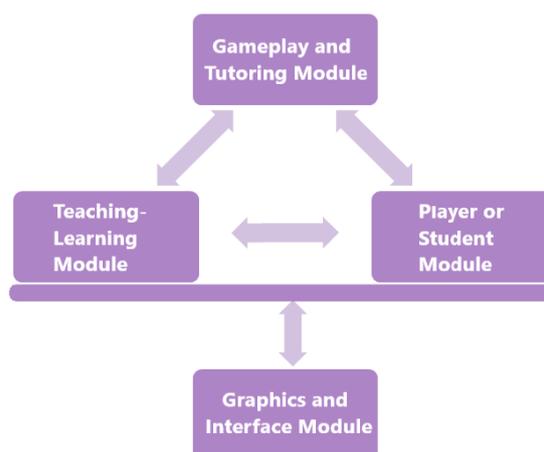


Figure 2: Conceptual Framework for Educational Games Design.

success or failure in certain activities. Finally, the **Graphics and Interface Module** is responsible for issues related to the interface and interaction environment with which the player interacts, in addition to graphic issues inherent to the game, such as artistic style, scenarios, character appearance and colors.

3.2 Constructive Process

First, the CFW was subdivided in a modular way. After this modularization and consequent separation of responsibilities, the process of inclusion of the components, called Criteria, that the educational game for Deaf children will need to meet, began. The process of defining the components of each module was as follows:

1. The module's responsibility was delimited. This was determined through two questions:
 - a) What exactly is this module intended for?
 - b) How far should the responsibilities of this module go without overriding the responsibility of the other modules?
2. Next, the subareas that would serve as the basis for the selection of the criteria were defined, then leading to the knowledge fields to support the module in question.
3. In cases where there were many intersections between relevant works in relation to a specific item, this element was incorporated as a criterion to the corresponding module. An example of this process, in the Graphics and Interface Module, can be seen in Figure 3.

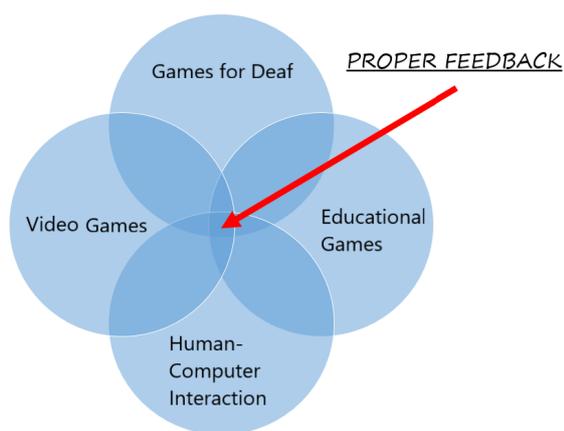


Figure 3: Example of Criterion Constructive Process.

3.3 Framework’s Criteria

Figure 4 brings up the relevant sets of criteria that the modules should handle. Within each of the modules, there are the necessary criteria for educational games to be adequate in order to support the Education of Deaf children.

In software, an adequate interface and interaction environment has several benefits for the user’s personal experience (Barbosa and da Silva, 2010). In digital games, in addition to the need for the graphical interface to have an adequate level of usability, there is a need for the graphics of the game to be particularly suitable for the target audience. In this type of software, the user spends much more time playing than interacting with the menus, so special attention should be paid to graphical issues.

Graphics are the way the game will display the designer’s world and tell his story. In educational games, graphics also have the role of visually transmitting the content to be taught. In the proposed Conceptual Framework, the Graphics and Interface Module has as its constituent criteria:

- **Colors and Shapes** (Novak, 2011) (Szcuka et al., 2013) (Plass et al., 2014) (Shneiderman, 2004): Colors must be strong and lively to please children. Most important elements on the screen should have highlight colors. Round shapes and vivid colors induce positive emotions. These positive emotions facilitate learning and improve understanding and transfer of knowledge.
- **Consistency** (Novak, 2011) (Melonio and Gennari, 2013) (Barbosa and da Silva, 2010): Using the same items in the same positions and orders on the interface helps the Deaf child to remember the features and their functions.
- **Simple Menus** (Lindgren et al., 2015) (Melonio

and Gennari, 2013) (Boscarioli et al., 2016): Interaction with menus should be simple and intuitive. Texts should be avoided, since, the written form of an oral language is not the natural language of the Deaf children. Illustrations are preferred to represent the possible options in the menus.

- **Meaningful Icons** (Barzilai and Blau, 2014) (Szcuka et al., 2013) (Malliarakis et al., 2014) (Mascio et al., 2013): Icons should be easily perceived and related to familiar concepts to the child. Also, the icons should not distract the child’s attention from the main task. The attention and focus of the player are essential so that the performance in the tasks are satisfactory and, consequently, the student can learn the concept being taught.
- **Cartoon Art Style** (Boscarioli et al., 2016) (Jabbar and Felicia, 2015) (Girard et al., 2013): Art with children’s appeal is recommended. The appeal and graphic attractiveness of a game has direct implication in the learning outcomes to be obtained with the educational game.
- **Proper Feedback** (Jabbar and Felicia, 2015) (Barzilai and Blau, 2014) (Azoubel, 2016) (Laamarti et al., 2014): The game communication with the player must always be as fast and comprehensible as possible, in graphic form or through the natural language of the Deaf.

Every game has its own gameplay. At the same time it has mechanics that make it unique, the game also has mechanics that resemble other games. These relatable mechanics allow the game’s categorization in one or more game genres.

In traditional commercial games, gameplay has the sole purpose of entertaining and amusing the player. Educational games, in turn, need to ensure learning of some content while entertaining, amusing, and maintaining the player’s motivation and attention. For this reason, the gameplay of an educational game must be intrinsically related to what one wishes to teach, to whom one wishes to teach, and to the degree of complexity in which the content may be taught. Therefore, the Gameplay and Tutoring Module is formed by:

- **Game Genre** (Laamarti et al., 2014) (Malliarakis et al., 2014) (Schell, 2014) (Dormann et al., 2013): It should be taken into account at the beginning of the game project. All gaming genres today can be adapted for educational games, but not all are suitable for children.
- **Instructions** (Vigil et al., 2014) (Jabbar and Felicia, 2015) (Khenissi et al., 2015) (Carvalho et al.,



Figure 4: Criteria of the Conceptual Framework.

2015): Instructions should be given at the beginning of the game, from video tutorial or images. If the game is not able to be self-explanatory to the child, its educational potential ends up being wasted as there will be no interest in the player interacting with what he/she does not understand.

- **Game Goals** (Song and Zhang, 2008) (Linek et al., 2010) (Mayer et al., 2014) (del Blanco et al., 2013): The goals need to be clear and appropriate for children. This means that the Deaf children who will play must understand its complexity. Also, the level of the goals' demands must be in accordance with the physical and cognitive capabilities of the target audience.
- **Meaningful Choices** (Werbach and Hunter, 2012) (Schell, 2014) (Schuytema, 2007): The game must offer possibilities for the player that have real impact in the game world.
- **Input and Controls** (Eseryel et al., 2014) (Melonio and Gennari, 2013) (Eseryel et al., 2014): Existing native input devices such as keyboard, mouse and touch screen should have higher priority over other ones. Number of buttons and commands available to the player should be limited to avoid excessive complexity.

- **Rewards** (Carter et al., 2014) (Song and Zhang, 2008) (Omar and Jaafar, 2009): There should be rewards for the player when he successfully completes his goals. However, the rewards must be delivered at appropriate times. That is, they should not be too frequent nor too far apart.
- **Association with Fields of Experience** (Beavis et al., 2015) (Kingsley and Olufemi, 2015) (Annetta, 2010): The goals and mechanics of the game should be directly related to the educational content the teacher wants to instruct and the capacities that the student must develop.

The purpose of computer-aided learning environments is to support teaching-learning in a given subject or area of knowledge. The main subject of this process is the student who uses the environment, be it an educational game, a tutoring system or another educational application. There is no way to ensure that the learner has effectively evolved his knowledge level and really learned if there is not any way of monitoring and evaluating his progress. Thus, the objective of the Student or Player Module is to assess the learner's performance and progress to verify that learning has actually occurred and to assist in cases where the expected goal has not been achieved. This

module has the following criteria:

- **Performance Evaluation** (Linek et al., 2010) (Murray, 2003) (Annetta, 2010) (Ibrahim and Jaafar, 2009): The game needs to have a mechanism to determine the amount of errors, accomplishments, time spent, among other indicators that measure the player's performance.
- **Scoring** (Niederhauser and Stoddart, 2001) (Barzilai and Blau, 2014) (Yusoff et al., 2009) (Malliarakis et al., 2014): It is important to have a visual indicator of player performance, based on the amount of achievements and value of action the player performs. Thus, the player himself can track, in real time, his progress and the outcome of his actions.
- **Improvement Suggestions** (Barzilai and Blau, 2014) (Murray, 2003) (Song and Zhang, 2008) (Nwana, 1990): When the player does not achieve the expected performance, it is important to have an assistance mechanism. Feedback should be given to the player, indicating skills to improve and how to do this, demonstrating what to focus on and what are his/her most common mistakes.
- **Difficulty Adaptation** (Dormann et al., 2013) (Schuytema, 2007) (Novak, 2011) (Annetta, 2010): The game should offer the option to choose level of difficulty. Alternatively, an automatic difficulty adjustment system may be included. This prevents a player from leaving the game, when having a hard time.
- **Hints** (Linek et al., 2010) (Ibrahim and Jaafar, 2009) (Virvou et al., 2005) (Dormann et al., 2013): Included in many games, tip system is a feature in which the player, who can not solve a problem and needs a real-time help, gets assistance. The tips can be, among others, suggestions of upcoming moves for the player that is having difficulty in proceeding during a match or a stage.

When the designer wants to build an educational game for Deaf children, the choice of game content is not trivial. The determination of which contents are taught to what ages is the result of years of study by researchers in the area of Education and Pedagogy.

Therefore, in order to ensure that content of an educational game is appropriate and relevant to the target audience, it is necessary to have a teaching methodology that supports the pedagogical basis of the game in question. These are the responsibilities of the Module of Teaching-Learning, which has the following criteria:

- **Fields of Experience** (Brasil, 2017) (Brasil, 2009) (Lindgren et al., 2015) (Felipe, 2012): Thematic concepts to be addressed in the game should

take into account the instructional objectives of Deaf Children's Education.

- **Rights of Learning** (del Blanco et al., 2013) (Brasil, 2017) (Brasil, 2009): The player must learn by playing relevant concepts and contents in Early Childhood Education, that support the child development.
- **Game Goals Association** (Arnab et al., 2015) (Kingsley and Olufemi, 2015) (Mayer et al., 2014) (Beavis et al., 2015): Each goal to be achieved in the game must be related to the teaching of a relevant concept or educational content.
- **Sing Language** (in Brazil's case: Libras) (Khenissi et al., 2015) (Mascio et al., 2013) (Melonio and Gennari, 2013) (Lindgren et al., 2015): The contents to be taught should be presented in SL. Language learning is one of the goals of games. The natural language of Deaf children is the Sign Language of their linguistic communities in each country.
- **Child Learning Support** (Khenissi et al., 2015) (Mascio et al., 2013) (Melonio and Gennari, 2013) (Lindgren et al., 2015): The game must be seen as a complementary tool for the teaching and learning of the child. It is not the main tool; the teacher presence must not be overlooked.

4 RESULTS

Alongside with empowering game designers with competence to build suitable educational games for Deaf children, the conceptual framework also has as result an authoring tool. The tool enables Deaf children teachers to generate educational games. It allows the access to a database of images and their respective themes for in-game use. In addition to accessing the database, the tool allows the teacher to include new signs and illustrations for later use by other authors who will require the tool to create their own games.

4.1 Authoring Tool

The proposed authoring tool is free to use, open and on-line. That is to say, teachers and illustrators from all over the country who want to contribute with new images, Libras' signs or other elements to the database, can easily include them in the server and share them. The tool has an intuitive interaction environment that can be used by professionals who work with education of Deaf children but do not understand programming.

As the framework supports the authoring tool, the teacher who wishes to create a game for his Deaf students using the authoring tool, will necessarily be grounded on the Conceptual Framework. Thus, when building a game from the tool, the game generated will be modularized according to the FWC's modular structure, that is, with each of its four modules.

In addition, the constituent criteria of the modules, which define the essential characteristics in an educational game for Deaf children, will be guaranteed in the game created. Therefore, the generated game will have clear objectives associated with the educational content. It will also have a form of evaluation and assistance to the player during his playing time, relevant content for the target age group, and interface and graphics adapted to the specificities of Deaf children.

4.2 Game Generated

Currently, the tool is prepared to generate educational games of the point-and-click adventure genre. As an example, a generated game is shown in Figure 5. In this game, the player needs to find all the animals exhibited in the stage scenario, while trying to avoid enemies and distractors. When the player successfully encounters an animal, he receives positive feedback and a balloon with the corresponding sign in Libras pictorial representation is displayed. Then, four options of words in Portuguese are presented, in order to verify if the player knows how this concept is represented in the Portuguese language as well. If the player is right once again, his score is increased. When the player finds all the required objects in the stage, within the time limit, he successfully ends the stage.



Figure 5: Generated Adventure Game.

This game is based on a study that carried out a research and consulting project at a school of the

Deaf in Recife city. This project elaborated games in Libras for the pedagogical work with Deaf children from 2 to 6 years old (Felipe, 1988). The referred project also based the development of a set of puzzle video games for Deaf children education (Canteri, 2014). The games work with semantic groups so that the child can learn signs and understand the concept of the sign and its relation to the group, such as hygiene, animals, transportation.

5 CONCLUSIONS AND FUTURE WORKS

This work presented contributions to the field of Game Design and Informatics in Education. The interdisciplinary and transdisciplinary nature of the research process, involving researchers from the Deaf Children's Education, the Human-Computer Interaction and Informatics in Education areas, ensures the robustness of the results.

The proposed framework enables professional game developers and game designers to build adequate educational games for Deaf children. The proposed framework was validated with its application in the development of a web authoring tool that allows the generation of educational games for Deaf children in a suitable and semi-automatic way.

On the other hand, the web authoring tool allows teachers of Early Childhood Education, without any programming or advanced computer skills, to create their own educational games for their students. This authoring tool was implemented in order to validate the proposed framework, that is, to demonstrate that it is possible to generate an educational game for deaf children. In this way, the paper answered both the research questions raised.

As first indicated future work, the authoring tool will be used and tested in schools, by teachers of Deaf children along with the incorporation of the resulting games in educational practice. It is also possible to point out as a potential future work the expansion of the conceptual framework to support the design of educational games for other ages and specificities.

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