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Exploring the Feasibility of Game-Based Tangible Resources in the Teaching of Deaf Preschoolers and their Hearing Peers

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ABSTRACT

In general, deaf education is a relatively neglected field, which needs attention, if societies want to ensure that schools are inclusive spaces, where learning is accessible. The present paper supports the development of a game-based tangible resource for deaf preschoolers, through co-creation and participatory action research, operationalized by the inclusion of teachers and educators in the process. Two case studies were developed, one quantitative survey and five focus group co-creation sessions, involving Portuguese sign language teachers, special education teachers, and teachers with only hearing students. Twenty-four teachers and educators answered the online survey and 19 participated in the focus groups. The results obtained in this study reinforce the need for more pedagogical materials, accessible for deaf children and can support the discussion around co-creation, participation, and representation as potential strategies to ensure it. The broad discussions raised by teachers and educators about the specificities of the educational needs of deaf children, while reinforcing school as still a disabling environment, can also support this and future approaches around accessibility, through proactive and digital inclusion-driven frameworks.

Keywords: Deaf and hard of hearing, Teaching, Game-based learning, Tangible resources, Preschool.

Introduction

In general, deaf education is a neglected field, which needs attention (Mackenzie & Smith, 2013). According to Smith and Allman (2019), deaf and hard-of-hearing students (DHH) tend to be organized into three different groups: (a) those using sign-based communication; (b) those using listening and spoken language, and (c) those using both sign and speech. Each group presents both similar and particular support needs.

According to data from General Directorate of Education and Science Statistics (*Direção Geral de Estatísticas da Educação e Ciência*; DGEEC), during the school year of 2017/2018, there were 87039 children with Special Educational Needs (SEN) in the Portuguese educational system, of which 3559 were attending preschool, both in private and public institutions. No data specifies how many preschool children need curriculum adaptations in regards to Portuguese Sign Language (*Língua Gestual Portuguesa*; LGP) implementation. Additionally, considering all school years and public schools, there are around 126 teachers of the recruitment group 920, this group specializes in support for children and young people with moderate, severe, or profound deafness, with severe communication and language problems or speech (DGEEC, 2018), and is commonly called the Special Education Teachers' group.

Several studies indicate that DHH children show lower performance in grammatical development as well as in mathematics (González Cuenca et al., 2020; Khwaldeh & Shah, 2010; Marschark et al., 2011; Nunes et al., 2008; Pagliaro & Kritzer, 2010; Sibanda & Tlale, 2019; Smith & Allman, 2020) and academic attainment in general (Edmondson & Howe, 2019; Khairuddin & Miles, 2020; Marschark et al., 2011; Smith & Allman, 2020). In regards to lack of grammatical development, that might happen because some of the DHH children do not have any linguistic and/or vocabulary development, when they start school (González Cuenca et al., 2020; Sibanda & Tlale, 2019). Regarding the low performance in mathematics, this might be due to the severe lack of math signs in LGP, which works as a complex to the acquisition of concepts by deaf children, being estimated that this group is about three and a half years behind hearing children in mathematics achievement (Nunes & Barroco, 2014). Pagliaro and Kritzer (2010) also suggested that this factor could be associated with a restriction that DHH children experience for incidental learning experiences, aligned with other inappropriate, or misguided learning opportunities. Additionally, Marschark et al. (2011) discussed the lack of early experiences with quantitative concepts, the delays in language development, the lack of teacher training, among a large pool of potential factors that promote lower performances in mathematics in DHH children.

In the study carried by Nunes et al. (2008) about deaf children's multiplicative reasoning, in comparison with their hearing peers, the main conclusion was that both groups of children benefited from the applied innovative intervention. Therefore, it is possible to argue that activities that benefit deaf children tend also to benefit their hearing peers, supporting their inclusiveness and transversal position in the curriculum.

DHH children may experience some barriers in the school setting at two levels: macro and micro. Macro-level barriers may include exclusionary governmental policies, stigmatizing attitudes towards deaf people, deaf culture and the usage of sign language, and the scarcity of adequate physical, human, and pedagogical resources. Regarding micro-level barriers, this included the low expectations and overprotection from teachers and peers, the prevalence of auditory learning environments, the lack of teaching materials in sign language, the lack of teachers' training, and the lack of deaf teachers (Munoz-Baell et al., 2011).

Deaf learners are visual learners (Ngobeni et al., 2020), therefore it is important and relevant to foster their inclusion through the integration of videos in the respective sign language (Neves & Sousa, 2019) and pictures in the classrooms (Ngobeni et al., 2020). These pictures, as stated by Ngobeni et al. (2020, p. 4), "should display the movement of the palm and fingers, position of signs and the appropriate facial expressions as displayed by a teacher in the picture".

Sign bilingual education

Sign bilingual education implies equal use of sign and oral language, where oral language is used in writing and reading. Munoz-Baell et al. (2011) add that it is also the materialization of a specific culture, the deaf culture, that acknowledges the distinct qualities of deaf communities as rightful language minorities.

This approach has shown to be an effective and feasible strategy for the inclusion of deaf children in countries where it is well established (Sibanda & Tlale, 2019), mainly when its early introduction is possible (Plaza-Pust, 2005). However, a factor that can contribute to the unsuccessful implementation of sign bilingual education is the late exposure that children sometimes have to sign language, especially relevant when parents and teachers are non-native signers (Sibanda & Tlale, 2019).

Game-based learning

Game-based learning is a methodology that 'takes' the educational potential of video games, serious games, or digital games to foster learners' motivation, helping them to be more involved, being creative, and giving them a more active role (Del Moral Pérez et al., 2018; Lamrani & Abdelwahed, 2020). Aside from its innovative role in the motivational system, it also supports learners in the development of their language and mathematical skills (Lamrani & Abdelwahed, 2020; Tokac et al., 2019). Considering the previously mentioned aspects about the lower performance that DHH children tend to have in language and mathematics, game-based learning may be something to consider when teaching these children. According to Wagner (1990), there are three types of games that can perform a role in language education: (1) games for repetition and memorization, that can support vocabulary training; (2) games for problem-solving, and (3) role-play and scenarios. The last two types of games can be seen as more complex, considering that they imply solving problems, while immersed in a social context (Meyer, 2013).

Using games in education is seen as having a positive impact on the learning process (Hamari et al., 2016). Games can be used in various domains, for example, education (Lamrani & Abdelwahed, 2020), having the potential to activate several cognitive systems, and support emotional induction and rewards systems (McGonigal, 2011). Games can also help in language structuring and reading skills acquisition (Del Moral Pérez et al., 2018). Besides that, games are also seen as crucial to explaining and understanding the world, allowing exploration, experimentation, and consequently learning (Frasca, 2009). In addition, Crookall (2007) stated that the use of games to teach language is encouraged as it fosters inclusion and creativity, and can provide challenge and competition to engage learners in autonomous learning (Meyer, 2013). To this extent, one aspect that game designers of learning material need to consider is the need of having a moment in the game where it is possible to give feedback to learners, as both feedback and teacher intervention are of high importance (Lamrani & Abdelwahed, 2020; Meyer, 2013).

Approach effectiveness

There is a lack of scientific data on the effectiveness of game-based learning approaches in the deaf population, nonetheless, there is evidence that some pedagogical strategies have helped enhance and facilitate learning and skills acquisition (Bouzid et al., 2016). A systematic literature review with a meta-analysis study, carried by Sousa & Costa (2018), concluded that game-based learning interventions are more effective than traditional approaches, usually expository. Moreover, it was

concluded that game-based learning approaches "can increase the learning process outcomes by at least 28%, and perchance by as much as 47% comparing with traditional approaches" (Sousa & Costa, 2018, p. 207).

Tokac et al. (2019) carried out a study where the first research purpose was to understand, when compared to a traditional classroom, what the relative learning effectiveness of game-based interventions on students' performance in mathematics from preschool to 12th grade was. They concluded that “mathematics video games contribute to a higher degree of mathematics achievement compared with traditional instructional methods” (Tokac et al., 2019, p.415).

As previously mentioned, there are several advantages in using game-based learning as an educational approach, mainly, because it helps children to be more motivated to learn, enabling their creativity, through a more active role, that can support the development of their language, mathematical, and memory skills (Avdiu, 2019; Del Moral Pérez et al., 2018; Lamrani & Abdelwahed, 2020; Tokac et al., 2019). Besides this, it also provides a safe environment for learners to experiment and make mistakes (Ortega, 1997). In the specific case of DHH children, it could also assist in the learning of sign language (Shivshwan, Wang, & Pongnumkul, 2016).

Cojocariu & Boghian (2014) enumerated several advantages of game-based learning, including the promotion of a positive attitude towards learning, the potential to support self-constructed learning, and the possibility of involving the entire classroom in an active learning activity. Moreover, this strategy can work as a transdisciplinary approach that allows to transversally work on skills and subjects, enhancing "research, problem-solving, leadership, teamwork, creativity, logic, taking decisions, adaptation, communicative and interaction skills" (Cojocariu & Boghian, 2014, p.641).

Co-creation and participatory action research

The cooperative/participatory paradigm is based on an epistemological position that emphasizes critical subjectivity, integrated with the centrality of co-constructed realities, supported by practices and experiences. In this participatory reality, the tension between objectivity and subjectivity is continuous and characterizes its ontology (Lincoln, Lynham, & Guba, 2018).

Participatory Action Research (PAR) intends to improve the different contexts through practice change-driven actions. This self-reflective inquiry empowers both researchers and participants to foster this change, reflect, and discuss it. Furthermore, it implies the understanding of the historical, cultural, and social context that embeds each phenomenon (Baum, MacDougall, & Smith, 2006), which is, in our research, operationalized with this article, aimed to the exploration of DHH preschooler’s educational context regarding mathematics and gaming. Moreover, PAR is seen as opening communicative spaces, that allow questioning and exploration, that allow the creation of richer and more emancipatory forms of education (Kemmis, 2006).

Broadly, the present research intends to be a variation of a co-creative process, that supports the collaborative construction of game worlds (Acharya & Wardrip-Fruin, 2019). This approach intends to support a player-driven formulation of a game design and game development process that, considering the very specific needs of the target audience, ensures proactive and comprehensive accessibility measures, included in the entire process, instead of only at the end line of it. Such a strategy can also be seen as an operationalization of the social model of accessibility (Fryer, 2021).

In the specific field of children and youth intervention, such participatory paradigms appear aligned with action-research, as relevant in the empowerment of the different stakeholders in the comprehension of the complex reality that embeds them, fostering their civic engagement, critical consciousness, learning, and, overall, educational change (Desai, 2019).

Based on these premises we developed the concept of the Inclusive Glossary of Mathematical Terms (*Glossário Inclusivo de Termos Matemáticos*; GIM) that is both an educational game and an action-research project. Capitalizing on the advantages of interactive media, particularly games in the learning process (de Freitas, 2018), it aims to meet the above-explored needs. The focus groups in case study 2, which will be explored next, were centered around the first conceptual lines of this resource (Figure 1), as a way to develop a co-creation-based, participatory approach to its development. It is a version of the classic memory card game. In our version, the matching cards are not the same to allow a narrative about them, which is very important for children at kindergarten age. The matching is based on the first and last images of an animation video, seen by the children on a screen by inserting the card in an interface, developed in the scope of the project with FabLAB technology. Besides the animation explaining each concept, the videos include the written word and the LGP gesture, materializing the game also as a bilingual glossary. The current version of the game is composed of two sets of cards and respective animations: the numbers between zero and nine and ten actions related to localization terms (e. g. above, below, in front of, behind).

Figure 1. Concept art for GIM interface, cards, and videos.

This is therefore a hybrid game in terms of technology, combining the physical medium of memory cards with digital videos that run on an interface designed from scratch for this project. This interface can be described as an irregular triangular pyramid with a screen and a side slot, which integrates QR code reading technology. The adoption of the tangible is linked to the centrality of touch as a part of experimentation and, consequently, learning in preschoolers (Ardiel & Rankin, 2010), although it brings a load of complexity of execution and dissemination of the game. Given the hypothesis that this game can foster the interaction between deaf and hearing children, it was considered that a purely digital option, with any process of choosing cards on the screen, would be less effective in the promotion of social interaction. Among others, we expect that the cards in physical support, with illustrations of animals and "humanized" numbers, enhance situations of appropriation and exchange, as well as game dynamics with a larger number of children where the screen interface may even be dispensed with by the educator. Although the game is designed as an interface-screen/card/video set, it is expected that the letters per se assume an intrinsic interface value, as a means to stimulate attention, memory, and to exemplify some of the fundamental mathematical concepts that are indispensable to any child.

The hybrid format of this game is aligned with the premise expressed by Poissant (2003), for whom humans are not yet ready to live without shadow, without texture, nor without leaving a trace, highlighting interface as a privileged channel of harmony with the other humans, where touch is fundamental. Considering the preschooler needs in terms of mathematics education, the game approaches two contents: location propositions and numbers from zero to nine.

Considering the lack of pedagogical resources, and how it is operationalized as one of the main barriers to the inclusion of deaf students in the schooling system (Munoz-Baell et al., 2011), the main aim of this project is to ensure the success of GIM, by involving teachers and educators from the creative phase, through a PAR methodology. Therefore, in this specific study, we intended to diagnose the pedagogical needs of teachers of deaf and hearing children regarding the teaching of LGP and mathematics.

To achieve such goals, we explore different, yet complementary case studies. More specifically, case study 1 frames a more quantitative, inquiry-based approach, where a survey was used to understand the audience needs and current practices in game-based and instructional teaching of preschoolers in an integrated perspective, case study 2 materializes a co-creation approach, where stakeholders were asked to participate in ideation focus groups. This research approach happens through a qualitative framing, based on the principles of co-creation, PAR, and media ethnography.

Overall, in the present article, we explore the feasibility of game-based tangible resources in the teaching of deaf preschoolers and their hearing peers, through a quantitative community diagnosis with teachers and educators, aligned with co-creation focus groups that included both SEN and deaf teachers. Therefore, this bilingual education approach, intends also to ensure accessibility and representation of deaf culture, through an evidence-based and participatory strategy.

Methods and Materials

Case study 1

Sampling

This case study adopted a non-probabilistic sample, operationalized through the open dissemination of an online survey to an already built group of partners in the field. This process resulted in a sample of 24 participants, divided into two groups. The first group was composed of education professionals from a regular school (N = 11). The second group was composed of LGP teachers, LGP interpreters working in schools, and special education teachers working with deaf children (N = 13). The second group included deaf people. The existence of two groups intended to ensure an inclusive sample, where deaf professionals' voices were represented. Therefore, a non-probabilistic approach was adopted, through convenience sampling procedure, based on existing contacts with schools, and with groups of professionals working on the field. Participants were between 25 and 60 years old (M = 42.63; SD = 9.29). Gender balance was not possible to ensure based on the professionals that volunteered to participate, and the sample was only composed of females. The group was composed of 10 LGP teachers (41.70%), 9 preschool educators (37.50%), 4 special education teachers (16.70%); and 1 school coordinator (4.20%).

Regarding professionals working with deaf children (N = 13), 10 (76.90%) were working exclusively with this population, while 3 (23.10%) professionals were working in the so-called mixed classrooms (with both deaf and hearing children). Also considering this group, 11 (84.60%) professionals were working simultaneously with children with and without cochlear implants, while the remaining 2 (15.40%) were working only with children without cochlear implants.

Regarding the professionals from regular schools (N = 11), it is possible to highlight that most of them have no teaching experience with deaf children (N = 9; 81.80%). Two professionals mentioned previous experience with this population (N = 2; 18.20%).

Regarding the usage of games in their daily lives and considering the full sample, most of the professionals played games "several times a month, but not weekly" (N = 6; 25.00%), followed by professionals who played games "sporadically" (N = 5; 20.80%), "several times a week, but not daily"

(*N* = 4; 16.70%), "daily" (*N* = 4; 16.70%), and "once a week" (*N* = 3; 12.50%). Only two professionals mentioned they "never" (*N* = 2; 8.30%) play games in their daily lives.

Instruments

In this case study, we used two different questionnaires, one for professionals working only with hearing children and another for professionals working with deaf children, or in mixed classrooms. Both questionnaires intended to make a diagnosis of the existing pedagogical resources to teach basic mathematical concepts, and the existing game-based resources. Moreover, it aimed to explore the current state of the usage of game-based learning in the classroom. The two versions were developed to ensure the questions' adaptation to the different classroom realities, with or without deaf children.

The first questionnaire was divided into four sections: the first section had three demographic questions (age, gender, and their role in schools), one single-answer question, one dichotomous question, and one open-ended question; the second section had two dichotomous questions, two multiple-choice questions, one single-answer question, and one open-ended question; the third section had only two open-ended questions; finally, the fourth section had one Likert scale question, ranging from one (none) to four (much), two dichotomous questions and one open-ended question. The second questionnaire was divided into three different sections: the first had four demographic questions (age, gender, their role in schools, and the grade they teach), three single answer questions and one open-ended question; the second section had two dichotomous questions, two multiple-choice questions, one single-answer, and one open-ended question; the third and final section had two open-ended questions and one dichotomous question.

Procedure

The survey was applied online, after the filing of an informed consent form, that explained the aim of the study, and all the ethical procedures involved, namely regarding anonymity, confidentiality, and legal aspects. In the operationalization of such premises, the lack of demographic information collection allowed for anonymity and confidentiality for scientific dissemination purposes.

The quantitative data was gathered through Likert scales and multiple choices with descriptive statistics, through IBM's Statistical Package for the Social Sciences (SPSS), version 26. Open-ended questions were categorized considering words as the unit of analysis. Word frequency was then analyzed through descriptive statistics alongside the rest of the gathered data.

Case study 2

Sampling

The present case study was divided into professionals who work with hearing children and professionals who work only with deaf children or in mixed classrooms, the latter group was further subdivided into two distinct groups: professionals in Special Educational Needs (SEN) and professionals who teach LGP. The first group consisted of three participants (*N* = 3) and had one session of focus group. The second group, SEN teachers, consisted of nine participants (*N* = 9) of which five participated in one the first session and seven participated in the second session (four of the seven participants participated in both sessions). Lastly, the third group, LGP teachers, consisted of seven participants (*N* = 7) of which

five participated in the first session and six in the second session (similarly to the previous group, four participants of the six participated in both sessions). After all, five focus groups were held.

The existence of three different groups intended to ensure an inclusive sample, where deaf professionals' voices were represented. Therefore, a non-probabilistic approach was adopted, through convenience sampling procedure, based on existing contacts with schools, and with online groups of professionals working on the field. Moreover, gender balance was not possible to ensure based on the professionals that volunteered to participate, and the sample was only composed of females.

Instruments

For the five focus groups, two different PowerPoint presentations were used, one explaining the concept of the project and the proposed pedagogical resource – that was used in the first session of each group – and the other with the improvements that were suggested by the professionals (SEN teachers and LGP teachers) in the previous session. Additionally, a non-structured focus group script was also used, composed of four questions that intended to involve the participants in the creative process, through the exploration of their perceptions and needs.

Procedure

To support the preformed content analysis procedures, the above-described focus group sessions were held via Zoom, and recorded, with the express consent of all the participants. Recordings were then transcribed and coded, considering each sentence as a unit of analysis. The adopted coding is shown below.

- General observations about the game concept
    - Advantages of this pedagogical resource
    - Disadvantages of this pedagogical resource
    - Potential improvement points
    - Potential accessibility problems/lack of suitability for the target audience
- Currently adopted pedagogical approaches
    - Advantages
    - Disadvantages
- Attitude regarding game-based learning
    - Positive
    - Negative
- Identified needs
- Currently adopted resources
    - Used games
- Constraints to the implementation of game-based strategies in the classroom
- Specificities of deaf children educational process
    - Cumulative specific educational needs
- Inclusion-driven attitudes
- LGP related aspects
- General positive attitudes towards the project

The content analysis procedure was operationalized with NVIVO software, version 12, with 40.00% (two random focus group transcriptions) of the material being analyzed by two coders. According to the general recommendations (O'connor & Joffe, 2020), Inter Coder Reliability (ICR) was considered acceptable (87.23%).

All participants engaged in informed consent procedures, including that they could decide to opt-out at any time. The Zoom sessions were protected by passwords, as well as the resulting recordings, stored in systems that could only be accessed by the research team. Participating in the focus groups resulted in minimal risks to the teachers and educators.

Findings

Case study 1

All the professionals participating in the study agreed that games can have a relevant role in the learning process (*N* = 24). Regarding the specific skills or areas that can be promoted or learnt through games, 87.50% (*N* = 21) mentioned literacy, followed by problem-solving skills (*N* = 20; 83.30%), numeracy (*N* = 18; 75.00%), interpersonal relationship skills (*N* = 16; 66.70%), cooperation (*N* = 12; 50.00%), and digital skills (*N* = 12; 50.00%). Professionals working with deaf children were also asked about LGP, and all of them (*N* = 13) believed that gaming could ease the learning process of the language. Additionally, one professional (working only with hearing children) mentioned the potential role of games to learn rules, social norms, and to deal with the frustration associated with winning or losing.

Considering the differences between groups, the agreement of professionals working only with hearing children regarding skills promoted through games was generally higher than the agreement of professionals working only with deaf children or in mixed classrooms, as shown in Table 1, excepting for literacy.

Table 1. Frequency of professionals' agreement with skills potentially promoted through games, presented by skill category and organized by groups (*N* = 24)

	Total participants (*N* = 24)		Professionals working only with hearing children (*N* = 11)		Professionals working only with deaf children or in mixed classrooms (*N* = 13)	
	N	%	*N*	%	*N*	%
Literacy	21	87.50	9	81.82	12	92.31
Numeracy	18	75.00	10	90.90	8	61.53
Problem-solving skills	20	83.30	11	100.00	9	69.23
Interpersonal relationship skills	16	66.70	10	90.90	6	46.15
Cooperation	12	50.00	8	72.73	4	30.77
Digital Skills	12	50.00	6	54.55	6	46.15

Most professionals used games in their classrooms (*N* = 21; 87.50%), with three professionals mentioning they do not use games in their daily practice with children (12.50%). From the 21 using, 47.60% mentioned they use games on a daily basis (*N* = 10), 23.80% "several times a week, but not daily" (*N* = 5), 14.30% "several times a month, but not weekly" (*N* = 3), 9.50% "sporadically" (*N* = 2), and "once a week" 4.80% (*N* = 1).

Regarding the analysis split by group, it is possible to mention that 90.90% (*N* = 10) of the professionals working only with hearing children mentioned the use of games in their classrooms, and 84.62% (N =11) of the professionals working only with deaf children or in mixed classrooms mentioned similar practices. If considering the frequency of usage as a scale ranging from one (never) to six (daily), the first group also mentioned a more frequent use of games in the classroom (*M* = 5.40; *SD* = 0.97) than the second group (*M* = 4.36; *SD* = 1.63). Nevertheless, such differences are not statistically significant (*p* = .092), calculated through t-test for Equality of Means (equal variances not assumed; *F* = 6.50, *p* = .020).

When asked about the conditions that could support the usage of games in their classrooms, professionals mainly mentioned the need for more games in schools (*N* = 15; 62.50%), followed by the need to receive more training in the field of game-based learning (*N* = 11; 45.80%); the lack of time to implement such activities (*N* = 11; 45.80%); the lack of flexibility to implement such activities (*N* = 10; 41.70%); and the need for more computers in schools (*N* = 8; 33.30%). Moreover, one professional working with deaf children also mentioned the need for more bilingual games.

As shown in Table 2, professionals working with deaf children showed more frequent agreement with the indicated conditions to foster game-based learning in the classrooms, when compared with professionals working only with hearing children, specifically for the need of more games, computers, and training. The second one agreed more frequently than the first ones with barriers imposed by the lack of time and flexibility to implement such activities.

Table 2. Frequency of professionals' agreement with conditions that could support the usage of games in their classrooms, presented by condition and organized by groups (*N* = 24)

	Total participants (*N* = 24)		Professionals working only with hearing children (*N* = 11)		Professionals working only with deaf children or in mixed classrooms (*N* = 13)	
	N	%	*N*	%	*N*	%
The need for more games in schools	15	62.50	5	45.45	10	76.92
The need for more computers in schools	8	33.30	3	27.27	5	38.46
The need to receive more training in the field of game-based learning	11	45.80	3	27.27	8	61.54
The lack of flexibility to implement such activities	10	41.70	5	45.45	5	38.46
The lack of time to implement such activities	11	45.80	6	54.55	5	38.46

Regarding LGP, professionals from regular schools considered their students had low familiarity with the language, an average of 1.82 on a scale ranging from one and four (*SD* = 1.16). Nevertheless, the group consensually agreed (*N* = 11) with the relevance of hearing children having contact, and learning LGP as a second language in school.

Considering the open-ended question regarding the specific games used in the classroom, by the professionals that used them (*N* = 21; 87.50%), results presented a broad range of answers, some of them specifying game types (e.g. puzzles), specific games (e.g. domino), commercial games (e.g. IXL Maths), game mechanics (e.g. association), game creation platforms (e.g. Kahoot!), tangible materials to play (e.g. Lego blocks), or adopted strategies (e.g. games are created by me). Therefore, the created codings are not mutually exclusive and intend to reflect the information gathered, as mentioned by each participant. From a total of 21 participants providing valid answers, 61 game-related references were coded. Memory games and puzzles were the most used by participants (7 mentions; 11.48% of the coded material each), followed by: games involving association (6 mentions; 9.84% of the coded material); domino, games created by the teacher, and LGP games (4 mentions; 6.56% of the coded material each); board games and building word games (3 mentions; 4.92% of the coded material each); building blocks (Lego), tangram, threading games, loto, and Kahoot! (2 mentions; 3.28% of the coded material each). The rest of the codings were mentioned once (1.64% of the coded material each), and included: serialization games; social games; the Glory Game (in Portuguese "Jogo da Glória" - a board game); snakes and ladders; plug-in games; traditional games; mathematical games; "Jogos da Mimocas" (https://www.tcondeco.pt/produto/os-jogos-da-mimocas/); storytelling games; games with LGP linguist dices; digital games; categorization games; and IXL Maths (https://uk.ixl.com/).

Regarding the teaching of location prepositions, professionals working only with hearing children (*N* = 11), mentioned different pedagogical strategies and materials with a total of 11 participants providing valid answers, 23 coded units. Movement games (4 mentions; 17.39% of the coded material); using the classroom space, furniture and material; role-playing; and daily life examples (3 mentions; 13.04% of the coded material each) were the most mentioned. The full results are shown in Table 3.

Table 3. Content analysis for strategies to teach location prepositions (11 valid answers; 23 coded units)

Coding	Number of mentions	%
Movement games	4	17.39
Using the classroom space, furniture, and material	3	13.04
Role-playing	3	13.04
Daily life examples	3	13.04
Stories	2	8.70
The chair game	2	8.70
Drawings	1	4.35
Mnemonics	1	4.35
Image games	1	4.35
Building blocks (Lego)	1	4.35
Outdoor activities	1	4.35
Using images	1	4.35

Still considering the same group, but now regarding the open-ended question "Please describe the strategies you use to teach numbers (from zero to nine)?", the provided answers also included a wide range of pedagogical approaches and materials, resulting in 23 coded units, from 11 valid answers. Quantifiable daily life examples were the most mentioned (7 mentions; 30.43% of the coded material). The full results are shown in Table 4.

Table 4. Content analysis for strategies to teach numbers, from zero to nine (11 valid answers; 23 coded units)

Coding	Number of mentions	%
Quantifiable daily life examples	7	30.43
Stories	2	8.70
Games (in general)	2	8.70
Using the classroom space, furniture, and material	2	8.70
Logical association	2	8.70
Cards with numbers	1	4.35
Group dynamics	1	4.35
Placement of facilitator materials in the classroom	1	4.35
Songs	1	4.35
Building pedagogical materials with children	1	4.35
Board games	1	4.35
Dice games	1	4.35
Card games	1	4.35

When asked if the LGP learning process could be facilitated through a game and why, 12 of the 13 professionals working with deaf children described their attitudes and beliefs on the subject, highlighting different potentials of games, resulting in 18 coded units. The potential of games to enhance or promote learning was the most mentioned by participants (5 mentions; 27.78% of the coded material). Another frequently mentioned aspect is the relationship between the visual form of LGP and the potentialities offered by digital media, particularly games (3 mentions; 16.77% of the coded material). The remaining referred aspects (1 mention; 5.56% of the coded material each) included the potential of games to: foster attention/concentration; promote child development; support motivation-related processes; promote interaction; promote creativity; to provide multisensory experiences. The children's interest in digital technologies in general, and specifically for games was also mentioned as possibly enhancing the LGP learning process. One participant mentioned the learning embedded in the gameplay as a relevant factor and another one highlighted that games can be effective if working as a complement for the formal learning processes.

Aligned with the previously presented view of the professionals working only with hearing children (N = 11) these students should have contact and learn LGP as a second language in school, participants were asked to describe their views. Eleven valid answers were gathered and twenty units of analysis were coded. Raising awareness for the existence of people with different communication forms and gesture-based languages was the most discussed topic by the group (4 mentions; 20.00% of the coded material). Other discussed topics were related and included the relevance of communication, inclusion, and the potential relevance of learning LGP for childhood development (3 mentions; 15.00% of the coded material each). The relevance of LGP for the future adulthood of these students was also mentioned, as well as the need to start this learning process as early as possible (2 mentions; 10.00% of the coded material each). Communication as a matter of children/human rights, the relevance of building relationships, and gestures/non-verbal communication as the main pillar of all human communication were other discussed aspects in the gathered answers (1 mention; 5.00% of the coded material each).

Case study 2

During the five focus groups, several topics emerged while talking about the game and/or GIM project, of which the most mentioned were: *General observations about the game concept* (*N* = 222; 30.04%), appearing on five out of the five focus groups analyzed; *LGP related problems* (*N* = 125; 16.91%), appearing on five out of the five focus group analyzed; and the *Specificities of deaf children education process* (*N* = 104; 14.07%), appearing on four out of the five focus group analyzed. Additionally, the least mentioned topics were: *Advantages* (*N* = 2; 0.27%) of the currently adopted pedagogical approaches, appearing on two out of the five focus groups analyzed; *Positive* (*N* = 3; 0.41%) attitudes regarding game-based learning, appearing on two out of the five focus group analyzed; *Disadvantages* (*N* = 6; 0.81%) of the currently adopted pedagogical approaches, appearing on one out of the five focus group analyzed; and *Cumulative specific educational needs* (*N* = 6; 0.81%) of deaf children's when they also have other specific educational needs, appearing on one out of the five focus group analyzed. Nevertheless, it is also important to reference that there were topics that were not approached, namely *Negative attitudes* (in attitudes regarding game-based learning), *Currently adopted resources*, *Used games* (in *Currently adopted resources*), and *Constraints to the implementation of game-based strategies*. Excluding these nodes, all the detailed results are systematized in Table 5.

Table 5. Content analysis of the focus groups' most coded nodes (739 coded units; 5 coded items)

Codes	Number of coded units *N* (%)	Number of coded items *N* (%)
General observations about the game concept	222 (30.04)	5 (100.00)
Advantages of this pedagogical resource	53 (7.17)	5 (100.00)
Disadvantages of this pedagogical resource	20 (2.71)	5 (100.00)
Potential improvement points	60 (8.12)	5 (100.00)
Potential accessibility problems - lack of suitability for the audience	5 (0.67)	3 (60.00)
Currently adopted pedagogical approaches	31 (4.19)	5 (100.00)
Advantages	2 (0.27)	2 (40.00)
Disadvantages	6 (0.81)	1 (20.00)
Attitude regarding game-based learning	8 (1.08)	3 (60.00)
Positive	3 (0.41)	2 (40.00)
Identified needs	20 (2.71)	2 (40.00)
Specificities of deaf children educational process	104 (14.07)	4 (80.00)
Cumulative specific educational needs	6 (0.81)	1 (20.00)
Inclusion-driven attitudes	56 (7.58)	5 (100.00)
LGP related aspects	125 (16.91)	5 (100.00)
General attitudes towards the project	18 (2.44)	2 (40.00)

When analyzing the different groups of educators, there are different results. Among the hearing children's teachers, the discussion was focused on *Inclusion-driven attitudes* (*N* = 30; 53.57%), *General observations about the game concept* (*N*= 28; 12.61%), and the *Advantages of this pedagogical resource* (*N* = 20; 37.74%). Among the LGP teachers, the discussion was focused on *General observations about the game concept* (*N* = 92; 41.44%), *LGP related aspects* (*N*=80; 64.00%), and *Specificities of deaf children education process* (*N* = 68; 65.38). Likewise, SEN teachers also focused on *General observations about the game concept* (*N* = 102; 45.95%), *LGP related aspects* (*N* = 44; 35.20%) and *Specificities of deaf children education process* (*N* = 36; 34.62%). The detailed results are in Table 6.

Table 6. Content analysis of the focus groups' most coded nodes, by group (739 coded units; 5 coded items)

Codes	Teachers with only hearing children *N* (%)	LGP Teachers *N* (%)	SEN Teachers *N* (%)
General observations about the game concept	28 (12.61)	92 (41.44)	102 (45.95)
Advantages of this pedagogical resource	20 (37.74)	19 (35.85)	14 (26.42)
Disadvantages of this pedagogical resource	1 (5.00)	7 (35.00)	12 (60.00)
Potential improvement points	2 (3.33)	19 (31.67)	39 (65.00)
Potential accessibility problems - lack of suitability for the audience	1 (20.00)	1 (20.00)	3 (60.00)
Currently adopted pedagogical approaches	7 (22.58)	18 (58.06)	6 (19.35)
Advantages	0 (0.00)	1 (50.00)	1 (50.00)
Disadvantages	0 (0.00)	6 (100.00)	0 (0.00)
Attitude regarding game-based learning	0 (0.00)	7 (87.50)	1 (12.50)
Positive	0 (0.00)	3 (100.00)	0 (0.00)
Negative	0 (0.00)	0 (0.00)	0 (0.00)
Identified needs	0 (0.00)	14 (70.00)	6 (30.00)
Currently adopted approaches	0 (0.00)	0 (0.00)	0 (0.00)
Used games	0 (0.00)	0 (0.00)	0 (0.00)
Constraints to the implementation of game-based strategies	0 (0.00)	0 (0.00)	0 (0.00)
Specificities of deaf children educational process	0 (0.00)	68 (65.38)	36 (34.62)
Cumulative specific educational needs	0 (0.00)	0 (0.00)	6 (100.00)
Inclusion-driven attitudes	30 (53.57)	15 (26.79)	11 (19.64)
LGP related aspects	1 (0.80)	80 (64.00)	44 (35.20)
General attitudes towards the project	8 (44.44)	10 (55.56)	0 (0.00)

By analyzing the Pearson correlations, calculated through the similarity of the coded words by node and case, the following dendrogram was elaborated (Figure 2). Through the mapping of the obtained correlations, it is possible to highlight that LGP related aspects and specificities of deaf children's educational process were the more correlated nodes (r = 0.98). SEN teachers were the group that made more observations about the game concept (r = 0.94), while LGP teachers' statements were more linked to LGP related aspects (r = 0.94) and the specificities of deaf children's educational process (r = 0.93).

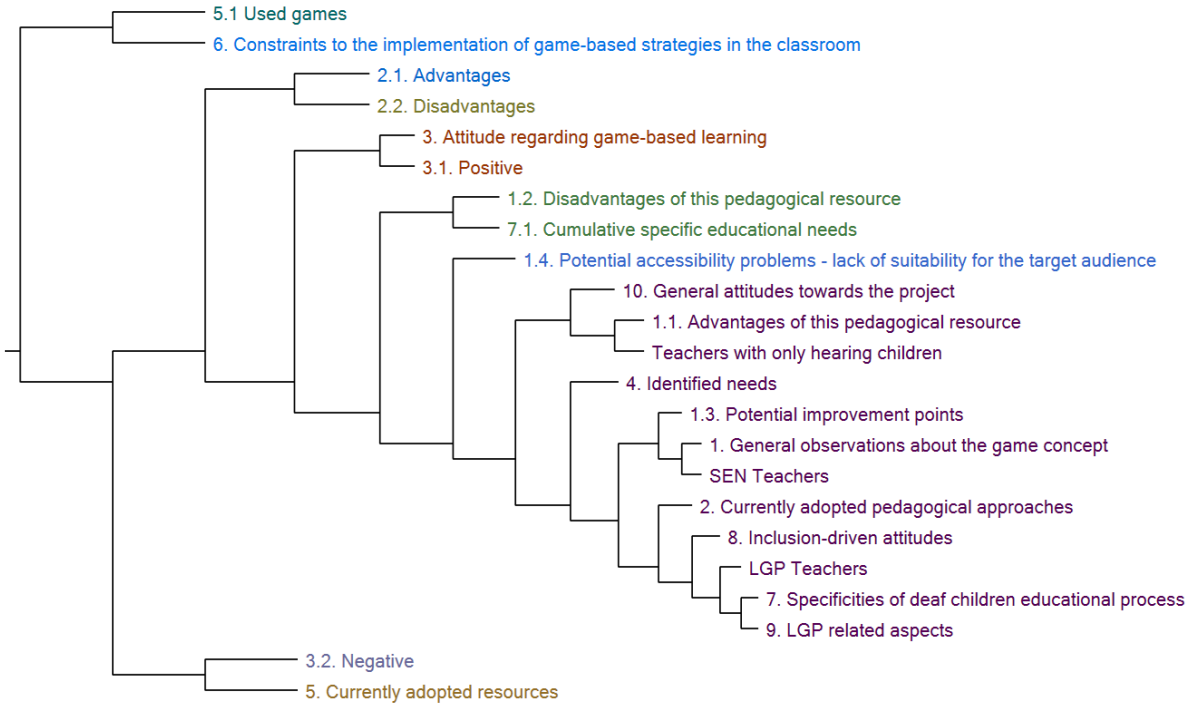

Figure 2. Dendrogram of Pearson correlations, by the similarity of the material coded in each case and node (5 coded items; 739 coded units)

Discussion

In this study, we proposed an approach, based on two different case studies, to support the successful development and implementation of an educational game aimed at deaf children and their hearing peers. The work was based on the assumption that involving teachers and educators since the creative phase could support its feasibility. Through this, we also aimed to diagnosis the needs of deaf children's teachers and educators regarding the teaching of both mathematics and LGP.

The first presented case study, based on an online survey, sustained those teachers overall agree with the potential of games in the learning process, with a very clear focus on the development of literacy, numeracy, interpersonal relationships, cooperation, and digital skills. This finding is aligned with previous studies that sustained the existence of positive attitudes from different stakeholders of the educational processes towards the pedagogical value of games (Saéz-Lopéz, Vázquez-Cano, & Domínguez-Garrido, 2015, Sousa, Henriques, & Costa, 2017). Moreover, it is interesting to note that most participants already implement games in their classrooms, although the usage frequency is very heterogeneous, and the lack of accessible games is acknowledged.

Through the operationalization of the above-explored diagnosis, the main identified needs included: the need for more games, that is more prevalent in the teachers that have deaf children in their classroom; the need for more training in game-based learning; the lack of time to implement game-based activities;

the lack of flexibility in the school schedule to include this type of innovative approaches; and the lack of digital access, materialized by the existence of a very limited number of computers in the school setting. Such findings reinforce the structural barriers for the inclusion of deaf children in classrooms, as previously explored by Munoz-Baell et al. (2011), and that seems to remain a reality in the current context.

Regarding the existing practices in the field of game-based learning, it is possible to highlight that the used games are very diverse in terms of genres and mechanics. This included memory games, puzzles, association games, and dominos. Games created by the teachers for specific purposes are also frequent and reflect the need for more materials, previously identified. Nevertheless, this aspect also reflects the creative side of teaching, which must be considered as an asset, through the implementation of co-creation processes able to capitalize it, such as in GIM.

Regarding mathematics, most participants use daily life examples as a pedagogical approach to the teaching of numbers, from zero to nine, which is the same logic we follow in our game. This can ensure the game is not very disruptive, in a way to introduce an innovation, while keeping the safety of familiar strategies, relevant with very young children. Regarding location propositions, strategies based on movement are the most adopted, which is also aligned with the developed animations. Briefly, GIM seems to be aligned with the already implemented practices, introducing an element of engagement and innovation, that can be also replicable in different settings and disseminated online, as an Open Education Resource (OER).

Concerning LGP learning, teachers highlight the relationship between the visual form of sign language and the potentialities offered by digital media in general, which supports the need for educational innovation in this field. Also, inclusion-driven attitudes were very prevalent, even in teachers that do not have deaf children in their classroom, agreeing that LGP should be taught in school, as a second language.

From the co-creation process, explored in case study two, the specific educational needs of deaf children and the aspects related to LGP were the most approached and discussed themes. Similar concerns were shown by LGP teachers and SEN teachers while hearing children teachers' discussions were more centered around the implementation of inclusion-driven pedagogical strategies in the classroom. The stronger prevalence and correlation of discussions around deaf children's educational needs and LGP teaching reinforces the educators' concerns, emerging from their professional experience. This reinforces the school environment and the existing pedagogical resources as disabling, through the exclusion of these children based on the inability of their context, particularly educational context, to effectively accommodate their needs.

Conclusions

The result obtained through the presented study is seen as cohesive support for the development of GIM but also for the development of other resources that are based on similar premises and needs. The general belief in the potential of games in the educational process, namely for literacy and numeracy, is accompanied by a lack of accessible games for DHH children, and an overall lack of digital access in schools. Therefore, even if science increasingly sustains the implementation of games in schools, a long way must be completed, to ensure this can be a feasible reality, even more, when we consider students with such specific needs as deaf children.

The inclusion of teachers and educators in the game design and game development process, through ideation, discussion, and effective implementation seems to be a feasible strategy to respond to some of the previously explored concerns. Also, while extensively discussing the specificities of their students' educational needs, teachers are supporting the accessibility of the developed resource,

operationalizing a proactive and inventive approach to digital inclusion. This approach also seems to address the inclusion pillars of representation and participation.

Limitations and Recommendations

The previously presented results arise from a process that was developed exclusively in Portugal, with Portuguese teachers and educators. Considering the extremely relevant socio-economic and cultural aspects of the formal education system, both in policies and stakeholders' attitudes, the replication of this study in other contexts would be crucial to understand the transnational differences and similarities. This extension would also solve a potential issue that arises from the limitation of the sample dimension.

Moreover, this study explores the initial steps of a development methodology that intends to be participatory and inclusive but does not yet explore the effectiveness of resources developed in such a way in the promotion of the defined learning outcomes. This is seen as a priority for the future, enlarged to include learning results, motivation and engagement aspects, and inclusion outputs, namely regarding the potential role of inclusive resources in promoting the interaction between deaf students and their hearing peers.

References

Acharya, D. & Wardrip-Fruin, N, (2019). Building worlds together: understanding collaborative co-creation of game worlds. *Proceedings of the 14th International Conference on the Foundations of Digital Games*, 1-5. https://doi.org/doi/10.1145/3337722.3337748

Ardiel, E. L., & Rankin, C. H. (2010). The importance of touch in development. *Paediatrics & Child Health*, *15*(3), 153–156. https://doi.org/10.1093/pch/15.3.153

Avdiu, E. (2019). Game-Based Learning Practices in Austrian Elementary Schools. *Educational Process: International Journal*, *8*(3), 196–206. https://doi.org/10.22521/edupij.2019.83.4

Baum, F., MacDougall, C., & Smith, D. (2006). Participatory action research. *Journal of Epidemiology & Community Health*, *60*(10), 854–857. https://doi.org/10.1136/jech.2004.028662

Bouzid, Y., Khenissi, M., Essalmi, F., & Jemni, M. (2016). Using Educational Games for Sign Language Learning - A Sign Writing Learning Game: Case Study. *Educational Technology & Society*, *19*(1), 129-141.

Cojocariu, V.-M., & Boghian, I. (2014). Teaching the Relevance of Game-based Learning to Preschool and Primary Teachers. *Procedia - Social and Behavioral Sciences*, *142*, 640–646. https://doi.org/10.1016/j.sbspro.2014.07.679

Crookall, D. (2007). Editorial: Second language acquisition and simulation. *Simulation and Gaming*, *38*(1), 6-8. https://doi.org/10.1177/1046878106298609

de Freitas, S. (2018). Are games effective learning tools? A review of educational games. *Journal of Educational Technology & Society*, *21*(2), 74–84.

Del Moral Pérez, M. E., Guzmán Duque, A. P., & Fernández García, L. C. (2018). Game-Based Learning: Increasing the Logical-Mathematical, Naturalistic, and Linguistic Learning Levels of Primary School Students. *Journal of New Approaches in Educational Research*, *7*(1), 31–39. https://doi.org/10.7821/naer.2018.1.248

Desai, S. R. (2019). Youth Participatory Action Research: The Nuts and Bolts as well as the Roses and Thorns. In K. K. Strunk & L. A. Locke (Eds.), *Research Methods for Social Justice and Equity in Education* (pp. 125-135). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-05900-2

DGEEC (2018). *Necessidades Especiais de Educação 2017/2018*. [online] Direção-Geral de Estatísticas da Educação e Ciência. Available at: http://www.dgeec.mec.pt/np4/224/ [Accessed 22 Sep. 2021].

Edmondson, S., & Howe, J. (2019). Exploring the social inclusion of deaf young people in mainstream schools, using their lived experience. *Educational Psychology in Practice, 35*(2), 216–228. https://doi.org/10.1080/02667363.2018.1557113

Frasca. G. (2009). Juego, videojuego y creación de sentido. Una introducción. *Comunicación, 7*(1), 37-44.

Fryer, L. (2021, July 11-15). *Introducing a Social Model of Media Accessibility*. IAMCR 2021 Conference - Rethinking borders and boundaries: Beyond the global/local dichotomy in communication studies [Paper presentation], Nairobi, Kenya.

Khairuddin, K. F., & Miles, S. (2020). School staff members' and parents' experiences of the inclusion of deaf children in Malaysian mainstream schools. *Education 3-13, 48*(3), 273–287. https://doi.org/10.1080/03004279.2019.1664403

González Cuenca, A., Lavigne Cervan, R., & Prieto Cuberos, M. (2020). Do Deaf Learners Reach the Necessary Linguistic Comprehension? *International Journal of Disability, Development and Education, 67*(1), 92–106. https://doi.org/10.1080/1034912X.2019.1682527

Hamari, J., Shernoff, D., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior, 54*, 170-179. https://doi.org/10.1016/j.chb.2015.07.045

Kemmis, S. (2006). Participatory action research and the public sphere. *Educational Action Research, 14*(4), 459-476. https://doi.org/10.1080/09650790600975593

Khwaldeh, S., & Shah, M. (2010). The adaptability of an open source learning management system for deaf children in Jordan. *2nd IEEE International Conference on Information Management and Engineering*, 34-39. https://doi.org/10.1109/ICIME.2010.5477480

Lamrani, R., & Abdelwahed, E. (2020). Game-based learning and gamification to improve skills in early years education. *Computer Science and Information Systems, 17*(1), 339–356. https://doi.org/10.2298/CSIS190511043L

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2018). Paradigmatic Controversies, Contradictions, and Emerging Confluences, Revisited. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE Handbook of Qualitative Research* (pp. 213-263). SAGE.

Mackenzie, I., & Smith, A. (2009). Deafness — the neglected and hidden disability. Annals Of Tropical Medicine & Parasitology, 103(7), 565-571. https://doi.org/10.1179/000349809x12459740922372

Marschark, M., Spencer, P. E., Adams, J., & Sapere, P. (2011). Evidence-based practice in educating deaf and hard-of-hearing children: Teaching to their cognitive strengths and needs. *European Journal of Special Needs Education, 26*(1), 3–16. https://doi.org/10.1080/08856257.2011.543540

McGonigal, J. (2011). *Reality Is Broken - Why Games Make Us Better and How They Can Change the World*. The Penguin Press.

Meyer, B. (2013). Game-Based Language Learning for Pre-School Children: A Design Perspective. The *Electronic Journal of e-Learning, 11*(1), 39–48.

Munoz-Baell, I. M., Alvarez-Dardet, C., Ruiz-Cantero, M., Ferreiro-Lago, E., & Aroca-Fernandez, E. (2011). Understanding Deaf bilingual education from the inside: A SWOT analysis. *International Journal of Inclusive Education, 15*(9), 865–889. https://doi.org/10.1080/13603110802669342

Neves, J. C., & Sousa, C. (2019). Developing Pedagogical Videogames to Support Math Learning in Deaf Children: A Work in Progress (Phases 1-3). Proceedings of the 12th European Conference on Game Based Learning, 1019-1023. https://doi.org/10.34190/GBL.19.169

Ngobeni, W. P., Maimane, J. R., & Rankhumise, M. P. (2020). The effect of limited sign language as barrier to teaching and learning among Deaf learners in South Africa. *South African Journal of Education, 40*(2), 1–7. https://doi.org/10.15700/saje.v40n2a1735

Nunes, L. & Barroco, J. (2014). O ensino da Matemática para os alunos surdos. Educação e Matemática, 126, 39-42.

Nunes, T., Bryant, P., Burman, D., Bell, D., Evans, D., & Hallett, D. (2008). Deaf Children's Informal Knowledge of Multiplicative Reasoning. *Journal of Deaf Studies and Deaf Education, 14*(2), 260–277. https://doi.org/10.1093/deafed/enn040

O'Connor, C., & Joffe, H. (2020). Intercoder Reliability in Qualitative Research: Debates and Practical Guidelines. *International Journal of Qualitative Methods, 19*. https://doi.org/10.1177/1609406919899220

Ortega, L. (1997). Processes and outcomes in networked classroom interaction: Defining the research agenda for L2 computer-assisted classroom discussion. *Language, Learning & Technology, 1*(1), 82-93.

Pagliaro, C. M., & Kritzer, K. L. (2010). Learning to learn: An analysis of early learning behaviours demonstrated by young deaf/hard-of-hearing children with high/low mathematics ability. *Deafness & Education International, 12*(2), 54-76. https://doi.org/10.1179/146431510X12626982043723

Plaza-Pust, C. (2005). Language contact in deaf bilingualism. In H. Leuninger & D. Happ (Eds.) *Gebärdensprachen: Struktur, Erwerb, Verwendung* (pp. 271-307). Helmut Buske.

Poissant, L. (2003). *Esthétique des arts médiatiques: Interfaces et sensorialité*. Publications de l'Université de Saint-Étienne; Presses de l'Université du Québec.

Saéz-Lopéz, J., Vázquez-Cano, E., & Domínguez-Garrido, M. (2015). Exploring Application, Attitudes and Integration of Video Games: MinecraftEdu in Middle School. *Educational Technology & Society, 18*(3), 114-128.

Sibanda, P., & Tlale, L. D. N. (2019). Challenges Experienced in the Practice of Sign Bilingual Education as a Strategy for Inclusion of Deaf Children in Mainstream Schools in Zimbabwe. *Journal of Social Sciences and Humanities, 16*(1), 1–12.

Shivshwan, K., Wang, C-J., & Pongnumkul, S. (2016). Exploring the Design and Evaluation of an Educational Game for Deaf and Hard-of-Hearing Students in Thailand. *i-CREATe 2016: Proceedings of the international Convention on Rehabilitation Engineering & Assistive Technology*, 1-4. https://doi.org/10.5555/3014393.3014401

Smith, C., & Allman, T. (2020). Diversity in deafness: Assessing students who are deaf or hard of hearing. *Psychology in the Schools, 57*(3), 362–374. https://doi.org/10.1002/pits.22310

Sousa, C. & Costa, C. (2018). Videogames as a learning tool: is game-based learning more effective?. *Revista Lusófona de Educação, 40*, 199-240. https://doi.org/10.24140/issn.1645-7250.rle40.13

Sousa, C., Henriques, S., & Costa, C. (2017). Are Videogames a Waste of Time? - The Pedagogical Value of Videogames: a Multi-Stakeholder Approach. *Proceedings of EDULEARN17 Conference*, 2336-2341. http://dx.doi.org/10.21125/edulearn.2017.1484

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning, 35*(3), 407–420. https://doi.org/10.1111/jcal.12347

Wagner, J. (1990). *Kommunikative spil i fremmedsprogsundervisningen*. Åløkke

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