Gameful approaches for the education of autistic children: a systematic mapping and research agenda

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***Abstract*—The education of autistic children is highly challenging and has been calling the attention of different types of professionals to offer solutions capable of helping in the education of these children. One of the most promising possibilities is the use of gameful approaches (*e.g.*, serious games, simulators, and gamification) in the teaching of autistic children. However, despite the recent efforts, it is difficult to understand how these approaches have been developed and applied. To face this problem, we conducted a systematic mapping investigating the design and application of gameful approaches for the education of autistic children. The main results indicate a predominance in the use of 2D games for personal computers, focusing on the contexts of nature, home, and city, analyzed by qualitative approaches. Our study mainly contributes to the areas of educational technologies, mental health, and game-based learning, by providing a general view and a research agenda on the design, use, and evaluation of gameful approaches in the educational process of autistic children.**

***Index Terms*—Gameful approaches, Autism, Autistic children, Systematic mapping, Research agenda**

I. Introduction

Cognitive skills are part of human life, and there are several ways in which one stimulation is possible [1]. However, for children with Autism Spectrum Disorder (ASD), the cognition stimulation is challenging [2]. That is because autistic people are born with a neurobiological developmental disorder [3]. Autism syndrome still has no cure and is characterized by difficulties in communication and learning [4], leading to a lower quality of life [5].

In recent years, one of the most promising techniques to stimulate the cognitive skill of autistic people is the use of gameful approaches (*e.g.*, serious games, gamification, and simulations) [6]. Despite the promising results regarding the use of gameful approaches in the education of autistic children, there is no consensus on which types of gameful approaches are being used, or even what types of technology have been used associated with the gameful approaches to improve cognition of autistic children.

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Facing this challenge, we conducted a systematic mapping to understand which gameful approaches have been used to stimulate the cognitive process of autistic children. The main results indicated that *i)* most studies present gameful approaches in 2D for personal computers, *ii)* most approaches are developed in the context of (*i.e.*, for teaching about) "nature", "home" or "city", *iii)* the most used elements in the area of games and gamification (*i.e.*, points, badges, and leader-boards) are not present in the studies, and *iv)* health professionals are not involved in most studies. The study contributes to different areas, such as educational technologies, mental health, and game-based learning, by proving state-of-the-art on the use of gameful approaches for the teaching of autistic children. We provided a research agenda recommending studies to be conducted.

II. Protocol

Systematic mapping was conducted based on the PRISMA protocol[1] that allows the conduction of a systematic process, from the collection of data to the writing of the results [7].

We carried out a systematic mapping with the main goal of identifying which gameful approaches have been used to stimulate the cognitive process of autistic children. To reach the purpose of the study, the following research questions (RQ) were defined: **RQ1**: What visual approaches have been used to present gameful approaches for autistic children? **RQ2**: What platforms have been used to present gameful approaches for autistic children? **RQ3**: What environmental contexts have been used in the gameful approaches for autistic children? **RQ4**: What graphic elements have been used in the gameful approaches for autistic children? **RQ5**: Which professionals and people (in general) are involved during the application of gameful approaches with autistic children?

Eligibility criteria were defined to filter the articles: **Inclusion criteria:** Primary empirical studies that present studies on the use of screen-mediated gameful approaches for the teaching of autistic children. We decided to analyze articles from 2017 to 2021 in the range of the last four years to achieve the most recent technologies. Also, the execution of the systematic mapping protocol started during the year

[1]https://prisma-statement.org/

2021. **Exclusion criteria:** *i)* out-of-scope studies; *ii)* gray literature; *iii)* redundant studies; *iv)* studies in languages other than English; *v)* duplicate studies; *vi)* secondary or tertiary studies.

For data collection, we chose to use the database Scopus[2], as it is a base that encompasses all other bases in the area (*e.g.*, ACM, IEEE Xplore e Springer) and is widely used in secondary studies of different areas.

The query/search string used was: TITLE-ABS-KEY (autism*) AND TITLE-ABS-KEY (“game-based”) OR TITLE-ABS-KEY (“serious game*”) OR TITLE-ABS-KEY (“simulation game*”) OR TITLE-ABS-KEY (games-with-a-purpose) OR TITLE-ABS-KEY (“educational game*”) OR TITLE-ABS-KEY (“learning game*”) OR TITLE-ABS-KEY (“gamif*”).

The system Parsif.al[3] was applied to remove duplicate studies, as well as to organize the selection process. Initially, the title and abstract were read to define whether a study met the inclusion criteria of the mapping, the process was conducted by three researchers who read the titles and abstracts. In the end, it was meeting between three researchers was conducted to discuss divergent points. The data collected were following the parameters defined in the research questions presented in Section II.

The query returned 375 studies, of which 10 duplicate studies were removed by the Parsif.al platform. At the begging of the screening step, 310 studies were rejected by the researchers for not meeting the inclusion criteria and 55 were accepted for the reading and data extraction stage. In this step, 13 studies were removed for not being available (even after a formal request to the authors). Five of them were identified as redundant and five were removed as they were identified as out of scope during the full read. Finally, 32 studies were included in the systematic mapping. Figure 1 presents the PRISMA diagram summarizing the process. The initial search took place on November 25, 2021, and the review process lasted 1 year. The protocol and dataset were registered in the OSF[4].

III. Results

Initially, Table I presents the Id, Title, and Citation of the 32 studies included in this review. To highlight the studies more clearly, the Ids are identified with the letter “S” followed by the corresponding number and the name of the study. For example S01, S02, S03, and so on and up to S32.

A. RQ1: What visual approaches have been used to present gameful approaches for autistic children?

This question aims to understand the technological aspects of games for children with autism. Understanding the main visual approaches and platforms can help researchers and professionals develop games to support the teaching of children with autism. Regarding the RQ 1, the 2D view is the most common, presenting in 18 studies (S01, S02 S05, S06, S07, S08, S09, S10, S12, S14, S16, S17, S19, S20, S22, S24, S25, S26, S27, S30, S32) with publications in all years. The 2D and 3D label corresponds to a game that uses both visualizations on the same platform (used only in the study S15). Although 3D is the second most common form of visualization, it is less explored, being contemplated in seven studies (S03, S11, S13, S18, S21, S28, S29). This may be due to the need for graphics processing resources and because developing applications in 2D is generally simpler. On the other hand, it is important to consider that 3D applications, especially in VR and AR, can help the autistic in the spatial and dimensional recognition of artifacts. One study used a robot (S31) and in two studies (*i.e.*, S04 and S23) was not possible to identify the visual approach used in the study. Figure 2 present a summary of the use of the identified interfaces and their applications over time.

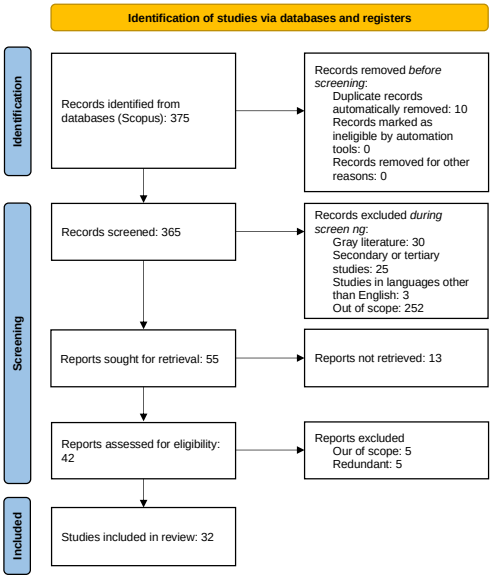

Fig. 1. PRISMA diagram (adapted from Page *et al.* [7])

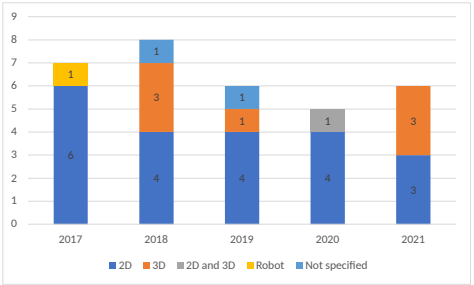

Fig. 2. *Visual approaches distribution over the years*

B. RQ2: What platforms have been used to present gameful approaches for autistic children?

Regarding the RQ2, the personal computer (PC) is the most common platform used in 16 studies (S01, S02, S04, S06, S07,

[2]https://www.scopus.com/home.uri
[3]https://parsif.al/
[4]https://osf.io/ev86q

TABLE I
SELECTED STUDIES

Code	Title	Citation
S01	'Emotiplay': a serious game for learning about emotions in children with autism: results of a cross-cultural	Fridenson-Hayo *et al.*, [8]
S02	A Demonstration Project for the Utility of Kinect-Based Educational Games to Benefit Motor Skills of Children with ASD	Vukicevic *et al.*, [9]
S03	A Design of Multipurpose Virtual Reality Game for Children with Autism Spectrum Disorder	Rahmadiva *et al.*, [10]
S04	A full-body interactive videogame used as a tool to foster social initiation conducts in children with Autism Spectrum Disorders	Mairena *et al.*, [11]
S05	A pilot study: a computer game-based assessment of visual perspective taking of four children with autism with high support needs	Korhonen *et al.*, [12]
S06	A Serious Game for children with Autism Spectrum Disorder as a tool for play therapy	Barajas *et al.*, [13]
S07	A Vocabulary learning of children with autism spectrum disorder (Asd): From the development to an evaluation of serious game prototype	Khowaja et al, [14]
S08	ACA game for individuals with Autism Spectrum Disorder	de Mira Gobbo *et al.*, [15]
S09	An empathic design approach to an augmented gymnasium in a special needs school setting	Takahashi *et al.*, [16]
S10	An inclusive reading programme for individuals with autism and intellectual disability using multi-media: Application of behaviour analysis and Headsprout early reading programme	Yakkundi *et al.*, [17]
S11	An interactive serious game to Target perspective taking skills among children with ASD: A usability testing	Ghanouni *et al.*, [18]
S12	Attention and working memory training: A feasibility study in children with neurodevelopmental disorders	Kerns *et al.*, [19]
S13	Autistic youth in 3D game-based collaborative virtual learning: Associating avatar interaction patterns with embodied social presence	Wang *et al.*, [20]
S14	CoASD: A tabletop game to support the collaborative work of users with autism spectrum disorder	Silva-Calpa *et al.*, [21]
S15	CodaRoutine: A serious game for introducing sequential programming concepts to children with autism	Elshahawy *et al.*, [22]
S16	Development and testing of a game-based digital intervention for working memory training in autism spectrum disorder	Wagle *et al.*, [23]
S17	Educational e-book for children with and without developmental disorders	Pistoljevic and Hulusic [24]
S18	Effective learning design of game-based 3D virtual language learning environments for special education students	Lan *et al.*, [25]
S19	EmoTEA: Teaching children with autism spectrum disorder to identify and express emotions	Garcia-Garcia *et al.*, [26]
S20	Empowering children with ASD and their parents: Design of a serious game for anxiety and stress reduction	Carlier *et al.*, [27]
S21	Learning through VR gaming with virtual pink dolphins for children with ASD	Lu *et al.*, [28]
S22	Leo con Lula, introducing global reading methods to children with ASD	Gomez *et al.*, [29]
S23	LOLY 1.0: A Proposed Human-Robot-Game Platform Architecture for the Engagement of Children with Autism in the Learning Process	Paillacho Chiluiza *et al.*, [30]
S24	PlayCube: Designing a Tangible Playware Module for Human-Robot Interaction	Silva *et al.*, [31]
S25	Serious games as an aid in the development of people with intellectual disabilities	Sochocka *et al.*, [32]
S26	Serious games to teach emotion recognition to children with autism spectrum disorders (Asd)	Elhaddadi *et al.*, [33]
S27	Teaching literacy skills to French minimally verbal school-aged children with autism spectrum disorders with the serious game SEMA-TIC: An exploratory study	Serret *et al.*, [34]
S28	The development of an escape room–based serious game to trigger social interaction and communication between high-functioning children with autism and their peers: Iterative design approach	Terlouw *et al.*, [35]
S29	Toward emotional interactive videogames for children with autism spectrum disorder	Baldassarri *et al.*, [36]
S30	Use of Augmented Reality with a Motion-Controlled Game Utilizing Alphabet Letters and Numbers to Improve Performance and Reaction Time Skills for People with Autism Spectrum Disorder	Antão *et al.*, [37]
S31	Using a humanoid robot as the promoter of the interaction with children in the context of educational games	Freitas *et al.*, [38]
S32	Using interactive games to engage children with autism on visual impairment	Che Ku Mohd *et al.*, [39]

S10, S11, S12, S13, S15, S16, S17, S18, S25, S26, S27, S29), the mobile platform (*e.g.*, smartphones, tablets, and others) is the second most common described in eight studies (S08, S10, S19, S20, S22, S23, S25, S32), followed by virtual reality or augmented reality (VR/AR) platforms with four occurrences (S03, S21, S28, S30). One occurrence was identified for interactive installation, e-book, video game console, embedded device, and robot. In one study was not possible to identify the platform. Some of the solutions presented merge more than one platform. Therefore, the number of platforms found is superior to the number of analyzed papers.

Table II presents the relation between the three leading platforms and the visual approaches found. 2D visualization is present on all platforms. VR/AR platforms mainly use the 3D interface. It is important to note that VR/AR platforms can be processed on PCs or mobile devices, depending on the choice of gadget. It was not possible to identify this aspect in the reviewed works. Meanwhile, mobile platforms make use of 2D. This is probably because mobile devices have less computational power for graphics processing, although this has changed over the years.

TABLE II
RELATIONSHIP BETWEEN VISUAL APPROACHES AND PLATFORMS

	PC	Mobile	VR/AR	e-book	II	Console
2D	11	7	1	1	1	1
3D	4	-	3	-	-	-
2D and 3D	1	-	-	-	-	-
Not Specified	1	1	-	-	-	-

Key: PC: personal computer; VR: virtual reality; AR: augmented reality; II: interactive installation.

C. RQ3: What environmental contexts have been used in the gameful approaches for autistic children?

The identification of environments is important to understand the children's correlation of the game with the real world. The three most common environments were Nature (S01, S02, S04, S05, S07, S09, S12, S13, S20, S21, S23, S32), House (S11, S15, S18, S22, S25, S28), and City (S03, S13, S14, S18, S29). These may be the most chosen because they usually portray environments in which children with autism are inserted into their routines. The other contexts were Universe (S10, S20), Cartoons (S07, S08, S24), presentation of people (S19, S26), symbol (S06, S30), diverse (S16, S27), avatar (S31), maze (S29) and children's story (S17). Figure 3 shows a word cloud with the most common environment identified.

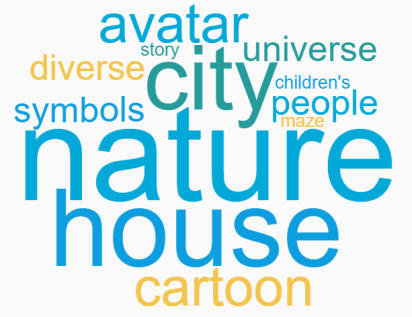

Fig. 3. Used environments words cloud

D. RQ4: What graphic elements have been used in the gameful approaches for autistic children?

We chose also correlated the graphic elements of the three primary environments, representing approximately 66% of the analyzed studies. Figure 4 shows the three sets, Nature, House, and City, and the identified cognitive elements. The font size represents the proportion of occurrence of terms, with the least frequent one appearance and the most frequent nine appearances. Some elements are found in more than one context as presented. We identified a lack of common gameful elements in the context of "Nature" and "City".

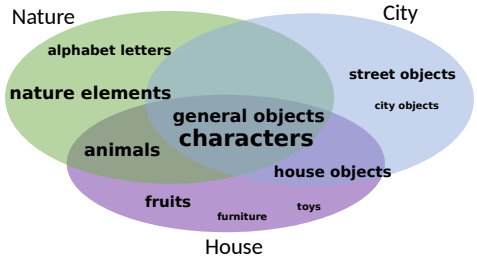

Fig. 4. Distribution playful elements into most common environments

E. RQ5: Which professionals and people (in general) are involved during the application of gameful approaches with autistic children?

In nine studies (S07, S08, S13, S16, S17, S21, S22, S27, and S29), only teachers accompanied autistic children. In five studies (S01, S06, S20, S26, and S04) only parents accompanied the children. In four studies (S03, S09, S12, and S18), children were accompanied by parents and teachers, while in two studies (S10 and S25) children were accompanied by parents and therapists. In one study (S11), parents and clinicians accompanied the children. In another study (S32), parents and educators accompanied the children. In another study (S28), psychologists and educators accompanied the children. In another study (S05), adults (not specified) accompanied the children. In another study (S02), educators accompanied the children. Finally, in another study (S14), therapists accompanied the children. In six studies (S15, S23, S24, S30, S31, and S19), it was not possible to identify if/who accompanied the children.

F. Limitations

Initially, it was not possible to access 13 studies, as they do not have public access. We request the studies to their respective authors by email, however, due to a lack of responses, the 13 studies were excluded from the review process. Also, the initial search took place in November 2021, so studies from 2022 were not included in the mapping. Therefore, important information may have been left out of the mapping results. As this is an analysis carried out by humans, data may have been collected incorrectly throughout the study, generating possible inconsistencies in the results. To mitigate this limitation, we followed strict analysis criteria by three researchers. Studies on the subject may not have been included because they are not identified by the search string or are not in the database used. To mitigate this limitation, we defined the string through a discussion between three researchers, as well as, we performed tests with several strings, selecting the one that found the best results. In addition, the search was made on a base that encompasses the main other bases in the area (*i.e.*, Scopus).

IV. Research agenda

Initially, there is a predominance in the use of a specific visual approach (*i.e.*, 2D), as well as a predominance in relation to the use of personal computers for using the approaches. At the same time, it is known that independent approaches have used VR and AR individually. Given this, **we suggest that future studies can add gameful approaches and technologies such as VR and AR**.

The results of our mapping demonstrate a predominance of studies involving nature, home, and city environments. On the one hand, this clearly demonstrates a concern on the part of researchers in the area to work on fundamental aspects of the daily life of autistic children. On the other hand, there is a lack of studies that develop applications considering aspects of learning in general, such as school. Given this, **we suggest that future studies seek to go beyond conventional environments, proposing approaches that involve other types of environments**.

Our studies also show that there is a predominance of those who accompany the children during the studies. In most studies, only teachers and parents accompany children. If, on the one hand, this is important and demonstrates a concern on the part of parents and teachers (who are primarily responsible for the intellectual development of children), on the other hand also demonstrates that few studies have sought collaboration with health professionals, such as psychologists, neurologists, and therapists, who are also fundamental to understanding how playful approaches affect children's intellectual development. **we suggest that future studies involve other professionals in observing children using gameful approaches**.

V. Concluding Remarks

In recent years, the teaching of autistic children has been a dominant subject in studies from different areas. One of the approaches used in the educational process of autistic children is the gameful approach. To understand community advances in this type of study, we conducted a systematic mapping to identify which gameful approaches have been used to improve the learning outcomes of autistic children. We aim, as a future study, to expand the scope of the mapping, answer different research questions, as well as conducting a bibliometric analysis, and a meta-analysis.

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