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Studying the effects of computer serious games on people with intellectual disabilities or autism spectrum disorder: A systematic literature review

Stavros Tsikinas | Stelios Xinogalos

Department of Applied Informatics, School of Information Sciences, University of Macedonia, Thessaloniki, Greece

Correspondence
Stavros Tsikinas, Department of Applied Informatics, School of Information Sciences, University of Macedonia, 156 Egnatia Street, GR-54636, Thessaloniki, Greece.
Email: s.tsikinas@uom.edu.gr

Abstract

This study examines the available literature on the effects of serious games on people with intellectual disabilities or autism spectrum disorder. The studies were categorized based on the limitations in skills that these people address. Fifty-four studies were selected, from different data sources. These studies address limitations in intellectual functioning and adaptive behaviour. The results showed that the majority of studies on the effects of serious games for people with intellectual disabilities or autism spectrum disorder had a positive impact. Also, most studies for people with autism aim to improve social and communicational skills, whereas conceptual and cognitive skills were mainly observed in studies for people with intellectual disabilities. Although this study covers serious games in all platforms or delivery systems, the overwhelming majority of the presented studies include computer serious games. Computer-assisted learning through serious games is considered quite promising for people with intellectual disabilities or autism spectrum disorder.

KEYWORDS

autism spectrum disorder, effectiveness, intellectual disabilities, learning, serious games

1 | BACKGROUND

Intellectual disability (ID) is defined as a developmental disorder that affects people in adaptive behaviour and intellectual functioning (American Association of Intellectual Disabilities and Developmental Disabilities [AAIDD], 2013). Adaptive behaviour is defined as the ability of a person to live independently and function safely (Heward, 2009). The set of skills that adaptive behaviour covers, according to the AAIDD, are shown in Table 1. Intellectual functioning is primarily determined by a person's mental functions, which refer to the skills of reasoning and problem solving. In order to determine whether a person is intellectually disabled, a test to determine the intellectual abilities is held, that is, IQ test (AAIDD, 2013; Westling & Fox, 2004).

Autism spectrum disorder (ASD) is a neurological disorder that affects people mainly in social and communicational skills. Also, people with ASD tend to have repetitive behaviours (Lord, Cook, Leventhal, & Amaral, 2000). Opposed to ID, ASD is entirely heterogeneous, meaning that each individual with ASD might behave differently.

Due to the limitations in adaptive behaviour and intellectual functioning that people with ID and people with ASD have, the teaching methods differ from those of typically developed people. The main goal of teaching people with ID or ASD is to help them become valuable for the society they live in. In order to achieve this, the educators need to define personalized goals and apply the appropriate teaching methods (Polychronopoulou, 2010). The addition of serious games (SGs) in the learning process of people with ID and people with ASD was recently introduced (Bartoli, Corradi, Garzotto, & Valoriani, 2013; Delavarian, Bokharaeian, Towhidkhah, & Gharibzadeh, 2015).

SGs are digital games running mainly in computers that aim to fulfil additional purposes and not exclusively entertainment (Ritterfeld, Cody, & Vorderer, 2009). SGs have been used in a variety of fields, that is, Education, Health, Advertisement, Awareness, and Business

TABLE 1 Set of adaptive behaviour skills

Category of skills	Skill
Conceptual skills	Language and literacy Money Time Number Self-direction
Social skills	Interpersonal Social responsibility Self-esteem Gullibility Naïveté Social problem solving Ability to follow rules or obey laws Avoid victimization
Practical skills	Daily living Work related Healthcare Travel or transportation Schedules or routines Safety Use of money Use of telephone

Management (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Riedel & Hauge, 2011). Lately, researchers have developed SGs for more specific target audiences, such as people with ID and people with ASD (Bernardini, Porayska-Pomsta, & Smith, 2014; Brown et al., 2011). These games address different adaptive behaviour and intellectual functioning skills.

The aim of this article is to present the results of a systematic literature review on the effects of SGs on educating people with ID or ASD. The rest of the article is organized as follows. In Section 2, efforts for literature reviews on various aspects of SGs for people with ID or ASD are presented. Section 3 includes the review method that was followed in our systematic literature review, by defining the research questions (RQs) and introducing the decisions that were followed during the analysis of the studies. In Section 4, the results are presented and analysed, and Section 5 includes the discussion of the findings with respect to the RQs. Finally, Section 6 presents the conclusions that were drawn after the analysis of the studies and introduces the next steps of the research. In addition, the limitations of this systematic literature review are stressed out in Section 6.

2 | RELATED WORK

The main purpose of this systematic literature review is to identify the state-of-the-art research on SGs for people with ID or ASD. In order to complete this task, relevant existing literature reviews were studied and analysed. The relevant studies are presented in a manner that follows the design–development–evaluation path of SGs, just as the RQs presented in Section 3.

Connolly et al. (2012) present a systematic literature review on computer games and SGs, concerning their learning and engagement outcomes. The review categorizes the retrieved studies with respect to study design, primary purpose, and subject discipline or curricular areas. The findings that were presented showed that acquiring knowledge and understanding contents are the most common outcomes of computer games.

Cano, García-Tejedor, and Fernández-Manjón (2015a, 2015b) present a literature review on SGs for people with ID. The aim of this review is to examine existing SGs, categorizing them according to the outcomes extracted. In addition, the review presents studies that include game design or development methodologies. The main goal of this study is to identify the existing design methods of developing SGs for people with ID and find a unique generalized method. The researchers concluded that the game design principles and guidelines extracted from existing studies depend on the disability that each study has approached. However, this review includes other mental illnesses as well, such as schizophrenia, Alzheimer, and general learning disabilities.

Zakari, Ma, and Simmons (2014) classify SGs for people with ASD, based on design and technological decisions, such as hosting platforms, graphics, game features, and user interaction. Furthermore, this study classifies the extracted papers according to their learning outcomes. The researchers suggest taking into account certain design mechanisms, when developing games for people with ASD, for example, allow parents and teachers to avert players to have certain behaviours during gameplay and include a data analysis tool to observe the progress of the players.

Noor, Shahbodin, and Pee (2012) review 13 SGs developed for children with ASD, concerning different factors, such as the technology used and the purpose of the games. The main goal of the review is to examine SGs for children with ASD from 2007 to 2011 and review the SGs classification. According to the findings of this review, SGs for children with ASD have been developed for therapy, learning, or training. The researchers conclude that SGs are effective when developed as an education and a therapeutic tool.

Bellani, Fornasari, Chittaro, and Brambilla (2011) conducted a literature review on virtual reality (VR) solutions for people with ASD targeted to improve their social behaviour. The study includes eight VR environments, and valuable information is extracted. The researchers identified the number and year range of the patients that were included in the testing process. Also, the equipment of each intervention and the number or time of sessions are presented. Finally, the study includes the results of the evaluation from every included VR environment. The review concludes that VR environments can help the acquisition and improvement of social skills for people with ASD.

Grossard et al. (2017) present a literature review on SGs for people with ASD that aim to improve social skills, emotion recognition, and perception. The selection process of the 31 studies that were included in the review is presented. In addition, the researchers examine the design, usability, and clinical validation of the extracted games and aim to identify the principles that the design of the games was based on. Finally, it is concluded that SGs should be assessed for their purpose and that field experts and game design experts should collaborate actively.

The systematic literature review presented in this article aims to present the existing literature on the effects of SGs on people with ID and ASD, developed to address certain skills. By conducting this review, the researchers were able to extract valuable information regarding developing SGs for people with ID and ASD. The review covers all aspects of the game development process, that is, design,

development, evaluation, and result. The extracted studies are assessed based on the skills addressed, design methodologies (where applicable), technological decisions, target audience, learning outcomes, and evaluation decisions. A unique feature of this Systematic Literature Review (SLR) in comparison with the aforementioned reviews is that it analyses the available SGs both for people with ID and ASD in an attempt to provide comparative information for both cognitive disabilities. In this sense, the results for each RQ are discussed for both cognitive disabilities, highlighting at the end the main differences and/or similarities regarding the findings in both fields. It is our belief that researchers in both fields can benefit from this analysis.

3 | REVIEW METHOD

This study follows the guidelines of conducting a systematic literature review by Kitchenham (2004).

3.1 | Research questions

The goals presented in Section 2 will be achieved by defining a set of RQs. The RQs of the present study are

- RQ1: Which aspects of adaptive behaviour and intellectual functioning are covered by the available studies?
- RQ2: What kind of design methodology is recommended to employ for developing SGs for people with intellectual disabilities and people with ASD?
- RQ3: Which platform or delivery system is used to host SGs for people with intellectual disabilities and people with ASD?
- RQ4: Which testing methods are used to evaluate the effect of the SGs developed for people with intellectual disabilities and people with ASD?
- RQ5: Do SGs for people with intellectual disabilities or people with ASD improve the skills they address?

3.2 | Strategy

In order to obtain studies involving SGs for people with ID and people with ASD, the following search query was used:

("serious game*" OR "educational game*") AND (intellectual disabilit* OR autism OR cognitive disabilit*)

The search term was added in the following digital research databases: *Scopus*, *SpringerLink*, *ACM Digital Library*, *Science Direct*, and *IEEE Xplore*. The data extracted from the studies were stored using Microsoft Office Excel™.

The preliminary phase of collecting relevant studies included the evaluation of the obtained papers from their titles and their abstracts. During this phase, the potential included papers were stored, and the irrelevant or duplicate studies were discarded. Initial exclusion criteria were

- non-English studies;
- robotic solutions or physical games; and
- studies regarding other mental illnesses, such as ADHD and dementia.

3.3 | Studies analysis

As soon as the preliminary phase was completed, the full text of each potential included study was read. During this process, the studies were analysed based on the properties presented in Table 2.

3.4 | Quality assessment

After the studies' analysis was complete, the papers were filtered. In order to complete the process of selecting the studies, inclusion and exclusion criteria were used, based on the SLR protocol (Kitchenham, 2004), as presented in Table 3. It is important to notice that some included studies use entertainment games because they fulfil a "serious" purpose.

TABLE 2 Paper analysis properties

General properties
• Name of project or game, if available
• Author names
• Availability
Design properties
• Type of project or game (computer-based, app-based or console-based)
• Design methodology
Purpose properties
• Category of skills, based on the AAIDD definition
• Target audience
• Learning goal
Evaluation properties
• Number of participants
• Age of participants
• Evaluation method
• Context of evaluation
• Evaluation conclusions

Note. AAIDD: American Association of Intellectual Disabilities and Developmental Disabilities.

TABLE 3 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Studies from 2005 to 2018	Older than 2005
Game solutions	Educational software
Studies include design (preferably), development, and evaluation process	Studies that do not cover development or evaluation process
SGs that have been assessed on their purpose or in-game performance	SGs that have been evaluated for acceptance or usability

Note. SG: serious game.

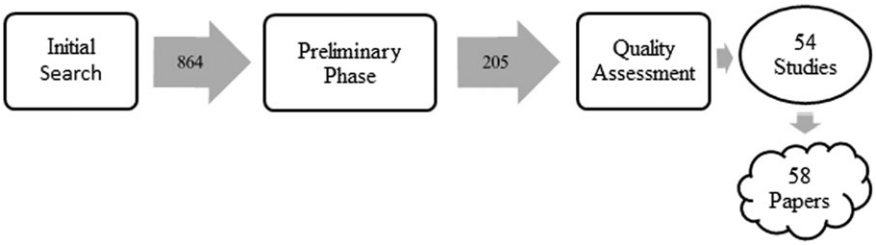

FIGURE 1 Flow of process

3.5 | Data extraction

To extract the data, the Microsoft Office Excel™ tool was used, and an Excel™ sheet was created, as shown in Appendices S1 and S2. The properties that were selected to extract data are presented in Table 2.

4 | RESULTS

The overall process of conducting the SLR lasted for 18 months. Studies regarding SGs for people with intellectual disabilities or ASD were retrieved. The entire process of study selection and the exact number of papers in each step are shown in Figure 1.

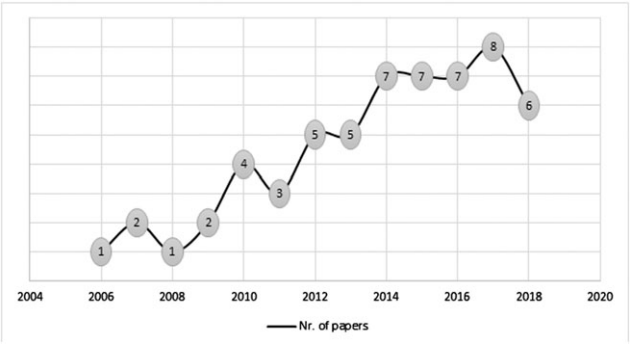

FIGURE 2 Flow of papers according to the year of publication

4.1 | Studies results

On the first search, 864 papers were found. The total number of papers that were collected on the preliminary phase was 205, and the rest were excluded as irrelevant or duplicate. During the quality assessment phase, the analysed studies were filtered, and 54 primary studies from a total of 58 papers were included in the SLR.

Figure 2 shows the number of papers published on each year. According to the year flow, the popularity of developing games for people with ID and/or ASD is growing. In addition, the inclusion of digital devices in the field of education is another reason of this growth (Soloway et al., 2001).

The majority of the published papers come from Journals (36), and 22 come from conferences. Also, the main subject area of journal publication, as shown in Figure 3, is Psychology (13). Other major subject areas are Social Sciences (11), Computer Science (11), and Medicine (10). The findings in Figure 3 show that developing SGs for people with ID and/or ASD is an engagement of the fields of Psychology, Social Sciences, and Computer Science. Thus, the importance of active collaboration between the field experts (psychologists, special need educators, and sociologists) and the development team is necessary.

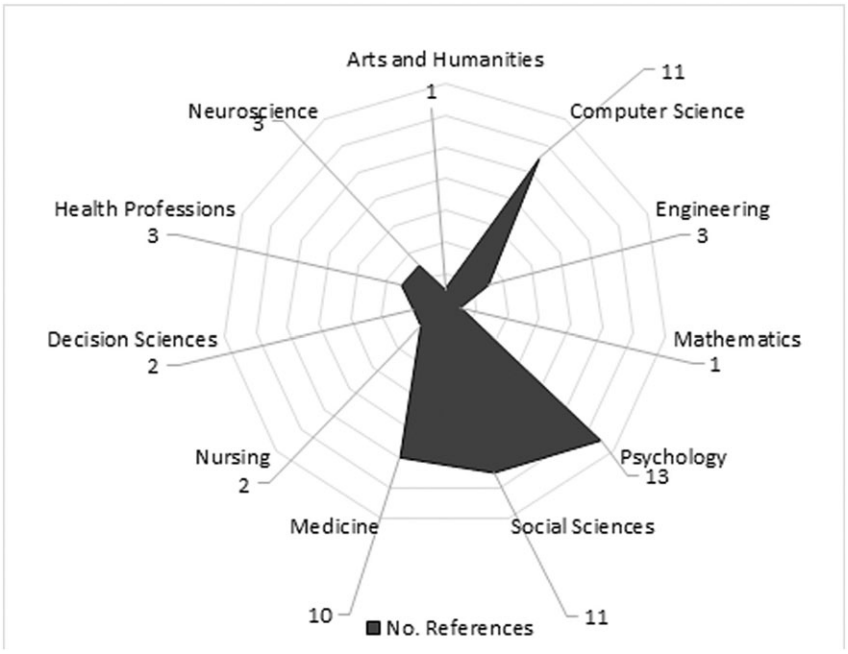

FIGURE 3 Subject areas of journal publications. Each journal might include multiple areas

5 | DISCUSSION

In this section, the findings of the studies are discussed with respect to the RQs that were defined.

RQ1 Which aspects of adaptive behaviour and intellectual functioning are covered by the available studies?

The primary studies were classified according to skills of intellectual functioning and adaptive behaviour. The classification was performed according to the skill they aim to improve.

In Table 4, the studies regarding people with ID are presented. First, it is observed that social skills were not addressed directly by any of the included studies. However, there were studies that improvements in social interactions were observed (Pareto, 2012). The studies of intellectual functioning are addressing skills such as attention and understanding (Rezaiyan et al., 2007), working memory (Delavarian et al., 2015), punctuation and comprehension (Segatto et al., 2017), and cognitive skills (Siberski et al., 2014; Tsimaras et al., 2014). Also, the study regarding performing recycling tasks is included, because the feature of problem solving is mainly presented in the study by Chang et al. (2014). In the conceptual skills, it is observed that all the skills are included apart from self-direction. However, the number of studies included in every skill is limited. Therefore, the effects of SGs for people with ID regarding each conceptual skill cannot be generalized. The SGs for practical skills are mainly focused on daily living (Burke et al., 2014; Freina et al., 2016) and work-related skills (Chang et al., 2011; Kwon & Lee, 2016; von Barnekow et al., 2017). The SGs are addressed to young adults with ID, and it can be concluded that this target audience is preferred for these sets of skills.

In Table 5, the studies regarding people with ASD are presented. The majority of the studies belong to the social skills category, and more specifically, they address interpersonal skills. In the interpersonal skills, the studies addressing social interactions (Barajas et al., 2017; Bernardini et al., 2014; Foster et al., 2010; Hourcade et al., 2012), recognition of emotions (Fridenson-Hayo et al., 2017; Grynszpan et al., 2008), and facial expressions (Gordon et al., 2014) are included. An interesting study is presented by Bossavit and Parsons (2018), where children with autism learn geography through collaboration and socialization. Thus, the targeted social skills are improved transparently and not directly through the game. In the conceptual skills category, all the studies belong to language and literacy skills, apart from the study of Pistoljevic and Hulusic (2017) presenting a SG that aims to improve both vocabulary and the concept of numbers in children with ASD. This is the case, because as stated in Section 1, people with ASD have limitations in social and communicational skills. Furthermore, the studies belonging to the language and literacy skill category aimed to improve people with ASD in speech (Hoque et al., 2009; Ploog et al., 2009; Rahman et al., 2010), whereas the study presented by McGonigle-Chalmers et al. (2013) addressed the skill of syntactical awareness. It can be concluded that it is more important to teach people with ASD to express themselves, rather than use the language correctly. Studies by Blum-Dimaya et al. (2010) and Zhu et al. (2015) addressed the practical skills of adaptive behaviour, and their goals were to help people with ASD implement leisure activities in their daily living and improve the hand movement, respectively. The study

TABLE 4 SGs classification, according to skills (intellectual disability)

Adaptive behaviour	Conceptual (four studies)	Language and literacy (one study)	Everhart, Alber-Morgan, and Park (2011)
		Money (one study)	Curatelli and Martinengo (2012); Curatelli, Martinengo, Bellotti, and Berta (2013)
		Time (one study)	Ripamonti and Maggiorini (2011)
		Numbers (one study)	Pareto (2012)
		Self-direction	
	Social	Interpersonal	
		Social responsibility	
		Self-esteem	
		Gullibility	
		Naïveté	
		Social problem solving	
		Ability to follow rules or obey laws	
		Avoid victimization	
	Practical (seven studies)	Daily living (two studies)	Burke, OBroin, and McEvoy (2014); Freina, Bottino, and Tavella (2016)
		Work related (three studies)	Chang, Chen, and Chuang (2011); Kwon and Lee (2016); von Barnekow, Bonet Codina, and Tost Pardell (2017)
		Healthcare (one study)	Salem, Gropack, Coffin, and Godwin (2012)
		Travel or transportation (one study)	Cano, Fernández-Manjón, and García-Tejedor (2016), Cano, Fernández-Manjón, & García-Tejedor, 2018)
		Schedules or routines	
		Safety	
		Use of money	
		Use of telephone	
Intellectual functioning	Cognitive (six studies)		Chang, Kang, and Liu (2014); Delavarian et al. (2015); Rezaiyan, Mohammadi, and Fallah (2007); Segatto, Melo, and da Silva (2017); Siberski et al. (2014); Tsimaras et al. (2014)

Note. SG: serious game.

TABLE 5 SGs classification, according to skills (autism)

Adaptive behaviour	Conceptual (seven studies)	Language and literacy (seven studies)	Hoque, Lane, El Kaliouby, Goodwin, and Picard (2009); McGonigle-Chalmers, Alderson-Day, Fleming, and Monsen (2013); Khowaja and Salim (2018); Pistoljevic and Hulusic (2017); Ploog, Banerjee, and Brooks (2009); Rahman, Ferdous, and Ahmed (2010); Serret et al. (2017)
		Money Time Numbers (one study) Self-direction	Pistoljevic and Hulusic (2017; duplicate study)
	Social (17 studies)	Interpersonal (17 studies)	Barajas, Al Osman, and Shirmohammadi (2017); Bernardini et al. (2014); Foster et al. (2010); Bono et al. (2016); Bossavit and Parsons (2018); Chung, Han, Shin, and Renshaw (2016); Ferguson, Gillis, and Sevlever (2013); Friedrich et al., 2015, Friedrich et al., 2015); Fridenson-Hayo et al. (2017); Golan and Baron-Cohen (2006); Gordon, Pierce, Bartlett, and Tanaka (2014); Gruarin, Westenberg, and Barakova (2013); Grynszpan, Martin, and Nadel (2008); Hourcade, Bullock-Rest, and Hansen (2012); Parsons (2015); Ribeiro and Raposo (2014); Tanaka et al. (2010); Uzuegbunam, Wong, Cheung, and Ruble (2015)
		Social responsibility Self-esteem Gullibility Naïveté Social problem solving Ability to follow rules or obey laws Avoid victimization	
	Practical (seven studies)	Daily living (one study) Work related Healthcare (four studies)	Blum-Dimaya, Reeve, Reeve, and Hoch (2010) Lu et al. (2017); Zakari, Poyade, and Simmons (2017); Xu, Chen, Zhu, and Xu (2015); Zhu, Cai, Ma, and Liu (2015)
		Travel or transportation (one study) Schedules or routines Safety	Simões, Bernardes, Barros, and Castelo-Branco (2018)
		Use of money (one study) Use of telephone	Caria, Paternò, Santoro, and Semucci (2018)
Intellectual functioning	Cognitive (six studies)		Bartoli et al. (2013); Daouadji Amina and Fatima (2018); Davis, Otero, Dautenhahn, Nehaniv, and Powell (2007); Hulusic and Pistoljevic (2012); Kerns, Macoun, MacSween, Pei, and Hutchison (2016); Roglić et al. (2016)

Note. SG: serious game.

by Caria et al. (2018) presents a set of three SGs that aim to assist people with ASD in using money in their daily activities. Another interesting study is that by Simões et al. (2018), where a SG is developed to help people with ASD to learn how to use bus transportation correctly and efficiently. Finally, the studies about intellectual functioning skills mainly comprise of a set of mini-games, rather than a specific game with a unique purpose (Bartoli et al., 2013; Hulusic & Pistoljevic, 2012; Roglić et al., 2016). Therefore, it can be concluded that gaming solutions that aim to improve intellectual functioning skills are preferred to include a set of mini-games.

Comparing the findings of SGs for people with ID and SGs for people with ASD, it is observed that researchers have not developed a gaming solution to embed in the learning process of social skills for people with ID, whereas SGs for people with ASD are mainly related to social interaction. Moreover, the studies regarding the effects of SGs on people with ASD (37) are more than twice than those on people with ID (17).

RQ2 What kind of design methodology is recommended to employ for developing SGs for people with intellectual disabilities and people with ASD?

A crucial process of developing SGs is to design the game in a way that it is acceptable to the user and effective (Charsky, 2010). Therefore, researchers try to follow design methodologies that would help them design successful SGs. All the available design methodologies extracted from the included studies have the end users as the basis for the design. We have to note, however, that only three studies for the effects of SGs on people with ID and four on people with ASD included the design methodology of the corresponding SGs.

The involvement of people with ID and people with ASD in the process of developing SGs is crucial and necessary (Tsikinas & Xinogalos, 2018). This design method is referred as *participatory design*. In the study by Cano et al. (2016, 2018), it is explained that the design process for their SG targeting on travel or transportation skills of people with ID included the insights of experts (psychologists and special education trainers), in order to have an acceptable game. The participatory design approach is also implemented in the study by Bernardini et al. (2014), where design workshops with practitioners and children with ASD were employed in order to design a SG targeting on interpersonal skills.

In the study by Ripamonti and Maggiorini (2011), a *user-centred approach* has been followed. In this approach, the design of the SG that aimed at improving time skills for people with ID began with a brainstorming process, where the learning goals and game elements were defined. In the next step, there was a playtesting session that examined the usability of the SG. After the usability testing, the design

document was created, and the production phase began. Although in this design phase the end users were not included, a special education professional was involved. A similar approach was followed by von Barnekow et al. (2017), in order to design IntegraGame, addressing the appropriate behaviour in a work environment for people with ID.

Another design method that is followed in developing SGs for people with ID and people with ASD is the *learner-centred approach*, through a 3T model, presented by Parsons (2015). This model is focused in the principles of Theory, Technologies, and Thoughts. It is a learner-centred approach of designing technologies for people with ASD and is implemented in studies included in this research (Bossavit & Parsons, 2018; Parsons, 2015). Through this design methodology, the targeted users become active members of the development team and have roles in the design and testing phases.

RQ3 Which platform or delivery system is used to host SGs for people with intellectual disabilities and people with ASD?

From the analysis of the studies, it is observed that PCs are used primarily (46), compared with game consoles (4) and mobile devices (7). In the studies by Bono et al. (2016) and Daouadji Amina and Fatima (2018), the SG developed could be hosted in both personal computers and tablet computers. Also, SGs presented in Caria et al. (2018) and Pistoljevic and Hulusic (2017) are developed to be hosted in the Web and therefore are available on both PCs and mobile devices.

In the studies where game consoles are used, the games are not developed by the researchers but are commercial games (Bartoli et al., 2013; Blum-Dimaya et al., 2010; Ferguson et al., 2013; Salem et al., 2012). Thus, using a custom SG to be hosted in a game console is not preferred. Possible factors that deter researchers from developing SGs for game consoles are cost, time, and licencing, as well as the fact that computers are ideal for the intended purpose.

As mentioned earlier, personal computers are the major systems to host SGs; however, some studies use assistive hardware to improve the experience of the users. The researchers of ECHOES used multisensor technologies, such as computer vision and multitouch screens (Foster et al., 2010), in order to track gestures and eye movement and gaze. Another SG that a touch screen is used as an input device is Eventaurs (McGonigle-Chalmers et al., 2013). The purpose of this study was to improve the syntactic awareness of children with ASD, by synthesizing phrases, by touching the correct sequence of words.

Another assistive input device for personal computers that is used in studies by Chang et al. (2011), Xu et al. (2015), Uzuegbunam et al. (2015), and Lu et al. (2017) is Microsoft Kinect™. A SG that uses the same technology is Kinempt (Chang et al., 2011). According to the researchers, Kinect™ allows users to be free of discomforting sensors and having to carry mobile devices. The technology of Kinect™ was also used in MeBook, a computer SG that assisted children with ASD in improving their social skills (Uzuegbunam et al., 2015).

Similar to Kinect™, there were studies that used a webcam as a motion-capturing technology (Chang et al., 2014; Gordon et al., 2014). In the study by Gordon et al. (2014), a webcam was used, in order to facilitate the CERT technology to capture the user's data.

The SG presented by Barajas et al. (2017) was developed to improve social, conceptual, and practical skills of children with ASD. Apart of a graphical user interface, the game includes also a tangible user interface made by MEGA BLOKS®. The players interact with the game by moving and placing the blocks in the correct position, through collaboration and social interaction with coplayers. So the researchers aimed to present a more realistic scenery to the players than solely using a graphical user interface.

New generation mobile devices, such as smartphones and tablet computers, have penetrated in the daily life of people. The number of smartphone users was expected to reach four billion in 2014 (EMarketer, 2014) and tablet computers surpassed one billion users in 2015 (EMarketer, 2015). The advances in the hardware of these devices have allowed developers to create high-quality games. Therefore, researchers have used smartphones and tablet computers, in order to develop SGs for people with ID and people with ASD (Bono et al., 2016; Hourcade et al., 2012; Ribeiro & Raposo, 2014). In particular, in the study by Hourcade et al. (2012), tablet computers were used on a set of mini-games, which goal was to improve social and collaborative interaction of children with ASD. The reason that tablet computers were selected was that touchscreens could be used easier compared with physical devices to navigate and interact. In the GOLIAH project (Bono et al., 2016), tablet computers and personal computers are used to improve the imitational and joint attention skills. Also, in MEDIUS, a SG that aims to improve reasoning and memory skills in children with ASD (Daouadji Amina & Fatima, 2018), the players interact with the game with a PC and a web camera or by a mobile device with the camera enabled.

By observing the platforms selected in SGs for people with ID and SGs for people with ASD, it is concluded that even though researchers use multiple types of platforms for hosting SGs targeted to people with ASD, researchers that developed SGs for people with ID use solely PCs and assistive technologies embedded in them.

RQ4 Which testing methods are used to evaluate the effect of the SGs developed for people with intellectual disabilities and people with ASD?

The testing methods used in the collected studies are presented in Figure 4. The most common testing method to evaluate the effects of SGs for people with ID (9) and people with ASD (21) is the pretesting–posttesting model.

Regarding the testing methods of evaluating SGs for people with ID, in-game evaluation (6) and observation (2) are also utilized. In order

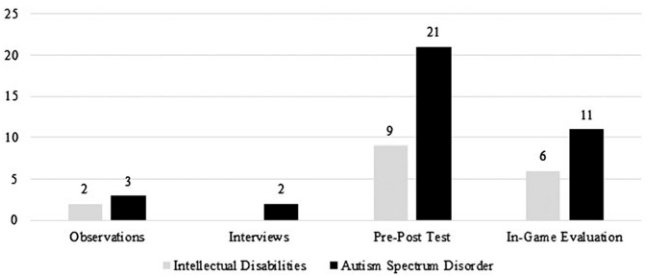

FIGURE 4 Testing methods used for people with intellectual disability and people with autism spectrum disorder

to evaluate the improvement of understanding the concept of death, Burke et al. (2014) assessed the game performance of four adult participants with ID, by tracking the game scores. Also, the Kinempt study, which goal was to improve vocational skills of adults with ID during work, used the same testing method (Chang et al., 2011), with two adults with ID participating in the evaluation. In addition to assessing the game performance of the participants, the researchers adopted the ABAB experimental technique, which helped them identify the differences in game performance and in general skill improvement. In particular, the participants were involved in two phases, the baseline phase (A) and the intervention phase (B). On the baseline phase, the instructions of performing work-related tasks were handed in by a job coach. On the other hand, in the intervention phase, the instructions were given autonomously by Kinempt (Chang et al., 2011).

The study by Curatelli et al. (2013) presented an educational solution, which aim was to improve the skill of managing money for people with ID. The researchers observed the behaviour of the participants during the intervention but also were observing their real life experiences, related to the subject. Another study that used observations in evaluating the effect of a SG is presented in the study presented by Ripamonti and Maggiorini (2011). The goal of this computer SG was to assist children with ID in reading the clock. The researchers were keeping track of the responses of six children (aged 8–18) with ID, by observing the reactions and the difficulties they might had faced (Ripamonti & Maggiorini, 2011). As mentioned, the vast majority of the studies used the pretesting–posttesting technique. The study by Chang et al. (2014) performed the pretesting–posttesting technique to evaluate the problem solving and recycling skills of three young adults (aged 20–25) with ID. The results after the intervention encouraged the researchers, because they were better than the pretest. Likewise, the study by von Barnekow et al. (2017) performed the pretesting–posttesting technique in two groups of students with ID (15–18 years old), a control group and a training group. The training group used the IntegraGame to learn correct behaviour in a work environment, whereas the control group was included in a real-life experience. After 14 months of intervention, the researchers indicated that the training group had better results in real-life exercises, compared with the control group.

In the study by Rezaiyan et al. (2007), the researchers used the pretesting–posttesting method to evaluate a set of computer SGs that aimed to improve the attention and understanding of 60 children with ID. The groups were split into control and experimental group and the pretesting–posttesting method was followed. In addition to performing a test before and after the intervention period, the researchers added another testing session 5 weeks after the intervention, in order to evaluate the long-term improvement. The researchers then concluded that even though after the postintervention testing, the experimental group had improved significantly in the skills the games addressed; the follow-up testing session showed no significant results. The same method was also followed in a study by Delavarian et al. (2015), but the follow-up testing session was encouraging. The participants were assigned in two different groups, a training and a control group. The training group consisted of seven children with ID (aged 9–14) and the control group of five children with ID and 12 typically developed children, aged 10–15, that participated only in the assessment process (Delavarian et al., 2015).

Regarding the testing methods of evaluating SGs for people with ASD, in-game evaluation (11), observation (3), and interviews (2) were also used, besides pretesting–posttesting. The study by Gordon et al. (2014) presents FaceMaze, which goal was to help children with ASD recognize and perform facial expressions. The evaluation process included 17 children with ASD aged 6–18 years and 23 children with typical development (8–16 years), in order to compare their expressions before and after the intervention. The researchers asked the participants to perform angry, happy, and surprised facial expressions. The researchers concluded that FaceMaze is an effective computer SG to teach children with ASD understand and perform facial expressions, because the results of typical developed and ASD children were similar. The study by Kerns et al. (2016) presents Caribbean Quest, a computer SG, which goal is to improve the attention and working memory of children with ASD and fetal alcohol spectrum disorder. The testing process comprised of pretest and posttest on 17 children aged 6–13 years, which included comparisons of game performance scores. Also, the emotional and behavioural responses were collected by the caregivers and parents of the participants.

In the study by Gruarin et al. (2013), a computer SG was developed to help children with ASD improve their social behaviour and collaboration skills. The testing method used was indirect observations, namely, interviews. In order to collect data, the researchers were conducting interviews with the mother of a young child with ASD aged 8 years old. The study by Fridenson-Hayo et al. (2017) presents a testing method that included both pretest and posttest tests for young children (6–9 years old) but also questionnaires for their parents. The use of questionnaires assisted the researchers to conclude if the players, during gameplay sessions, were motivated and enjoyed the experience.

The majority of the aforementioned studies took place in a non-formal learning context. Specifically, the examined SGs for people with ID were mainly used in a non-formal context, as extracurricular activities (10). Six SGs for people with ID were included in a formal and one in an informal learning context (Cano et al., 2018). As far as SGs for people with ASD are concerned, 23 SGs were included in a non-formal, 11 in a formal, and two in an informal learning context. In the study by Daouadji Amina and Fatima (2018), the experimentation setup is not defined.

Another extracted feature of the evaluation process in the included studies is the sample size of the participants. The mean sample size of participants included in both categories of SGs is approximately 20. Some studies mention the low sample size as a limitation that does not allow generalizing their conclusions (Lu et al., 2017; Zakari et al., 2017). An interesting remark is that the studies of conceptual skills for people with ID have a limited sample size, by not exceeding eight participants. Also, the SGs for people with ASD addressing social skills have a much larger sample size (e.g., 40, 65, or even 123 participants), compared with SGs for different adaptive behaviour or intellectual functioning skills.

As mentioned earlier, the majority of SGs for people with ID are targeted to students or adults. Therefore, the average age of the participants in the studies for people with ID is over 17 years old.

However, there are studies that the age of the sample size is not defined. SGs addressed to people with ASD are mainly addressed to children, and therefore, the average age of the participants is 10.7 years old.

RQ5 Do SGs for people with intellectual disabilities or people with ASD improve the skills they address?

In order to answer this RQ, the SGs that are presented in the 54 primary studies were classified and analysed. The classification is based on the skill categories they address and the evaluation results. Table 6 presents the classification of SGs for people with ID, and Table 7 presents the classification for people with ASD. There are studies addressed to people with ID and ASD, which are included in both tables. As shown in the tables, it appears that the majority of SGs included in the study improved the skill they addressed (43), compared with the studies with no significant difference after the intervention (9) and studies with no effect at all (2).

Regarding the effects of SGs on people with ID, as observed in Table 6, Burke et al. (2014) pointed out that the SG used in their study for helping children with ID understand the concept of death did not result to significant improvements because the levels of the SG were easy. As pointed out in Franzwa, Tang, and Johnson (2013), it is important when developing SGs to keep the balance between fun and learning. In addition, it is necessary when developing SGs to challenge the users, in order to keep their motivation high (Charsky, 2010).

The SGs that their measured effect was not significant are addressing specific skills, such as understanding the concept of death (Burke et al., 2014), improve the attention capacity level (Rezaiyan et al., 2007), and improve work-related tasks (Kwon & Lee, 2016).

As mentioned earlier, most of the studies included in the literature review improve the skills they address. "Downtown, A Subway Adventure" is a SG that aims to improve youth and young adults to travel independently, using public transportation (Cano et al., 2016, 2018). Although the researchers conducted 1-hr sessions (for 3 days) with the aim of assessing the design of the SG, it was also concluded that the participants improved their in-game performance (Cano et al., 2018). Also, the study in Everhart et al. (2011) describes a computer SG for children with ID that aimed to improve the conceptual skills of identifying numbers and letters. During the intervention period (12–14 weeks), the researchers observed improvements on the participants' in-game performance, and 2–4 weeks after the intervention, the skill level was maintained (Everhart et al., 2011). Thus, it was concluded that the particular SG could be used to improve the skills of understanding letters and numbers.

As mentioned earlier, researchers have utilized not only SGs but also several entertainment games in their studies. For instance, the researchers in the study by Salem et al. (2012) aimed to improve

TABLE 6 SGs classification, according to skill categories and their effects (intellectual disabilities)

Adaptive behaviour	Conceptual (four studies)			Curatelli and Martinengo (2012); Curatelli et al. (2013); Ripamonti and Maggiorini (2011); Everhart et al. (2011); Pareto (2012)
	Social Practical (seven studies)		Burke et al. (2014); Kwon and Lee (2016)	Cano et al. (2016), Cano et al., 2018); Chang et al. (2011); Freina et al. (2016); Salem et al. (2012); von Barnekow et al. (2017)
Intellectual functioning	Cognitive (six studies)		Rezaiyan et al. (2007)	Chang et al. (2014); Delavarian et al. (2015); Segatto et al. (2017); Siberski et al. (2014); Tsimaras et al. (2014)
Effect		No effect	Neutral (three studies)	Positive (14 studies)

Note. SG: serious game.

TABLE 7 SGs classification, according to skill categories and their effects (autism)

Adaptive behaviour	Conceptual (seven studies)		Ploog et al. (2009)	Hoque et al. (2009); McGonigle-Chalmers et al. (2013); Khowaja and Salim (2018); Pistoljevic and Hulusic (2017); Rahman et al. (2010); Serret et al. (2017)
	Social (17 studies)	Grynszpan et al. (2008)	Bernardini et al. (2014) and Foster et al. (2010); Golan and Baron-Cohen (2006); Ribeiro and Raposo (2014)	Barajas et al. (2017); Bono et al. (2016); Bossavit and Parsons (2018); Chung et al. (2016); Ferguson et al. (2013); Friedrich, Sivanathan, et al., 2015, Friedrich, Suttie, et al., 2015); Fridenson-Hayo et al. (2017); Gordon et al. (2014); Gruarin et al. (2013); Hourcade et al. (2012); Parsons (2015); Tanaka et al. (2010); Uzuegbunam et al. (2015)
	Practical (seven studies)		Zakari et al. (2017)	Blum-Dimaya et al. (2010); Caria et al. (2018); Lu et al. (2017); Simões et al. (2018); Xu et al. (2015); Zhu et al. (2015)
Intellectual functioning	Cognitive (six studies)	Roglić et al. (2016)	Daouadji Amina and Fatima (2018)	Bartoli et al. (2013); Davis et al. (2007); Hulusic and Pistoljevic (2012); Kerns et al. (2016)
Effect		No effect (two studies)	Neutral (six studies)	Positive (29 studies)

Note. SG: serious game.

motor skills of 40 children with ID using WiiFit™ and WiiSports™. These games, by using Wii Balance Board™, aid users to become physically active in an entertaining manner. After a week of the intervention period, the participants had significant improvements in performing certain moves, such as performing a one-leg stance (Salem et al., 2012).

Finally, in the study by Segatto et al. (2017), the researchers evaluated positively the SG for the game performance but also noticed physical activity engagements.

Regarding the effects of SGs on people with ASD (Table 7), Grynszpan et al. (2008) concluded that the effects of the computer SG they developed were poor. The goal was to help children with ASD understand the facial expressions and emotions during a conversation. They addressed the fact that rich interfaces "might have hampered learning transfer for the clinical group." Furthermore, in the process of evaluating Vockice, a SG that was developed to improve cognitive skills in children with ASD, the concentration level of the participants was decreasing during the intervention (Roglić et al., 2016). Project ECHOES is comprised of a set of 12 learning activities and computer games, aiming to improve social and communicational skills of children with ASD (Bernardini et al., 2014; Foster et al., 2010). In the evaluation process of ECHOES, the researchers concluded that there were no improvements in social responsiveness to the participants' daily life. Similar results were observed during the evaluation of the Mind Reading computer game, which goal was to help children with ASD understand facial expressions and emotions. Although the in-game performance of the participants improved, there were no improvements in generalizing these skills (Golan & Baron-Cohen, 2006).

There were entertainment games that were used for improving skills of people with ASD. In particular, in the study by Bartoli et al. (2013), two commercial games were used in order to help children with ASD improve their attention skills, namely, Kinect Sports™ and Rabbids Alive & Kicking™. After the intervention period, the researchers concluded that the participants increased their attention level (Bartoli et al., 2013). Also, in the study by Blum-Dimaya et al. (2010), Guitar Hero™ was successfully used to assess the leisure activity of children with ASD. During the intervention period, the researchers observed improvements in game performance, and this improvement was maintained a month after the intervention.

Hourcade et al. (2012) present another study with significant improvements. The researchers developed a set of four games aiming to improve the social and collaborative skills of children with ASD. When the intervention period ended, they concluded that the participants improved their social behaviour during school. Fridenson-Hayo et al. (2017) present a study based on Emotiplay, which is a SG developed to assist children with ASD improve their emotion recognition task (Fridenson-Hayo et al., 2017). The results of the two-phase evaluation process indicated that the participants improved their emotion recognition tasks, for emotions presented through voice, face, and body language.

Another SG that improved the targeted skills is presented in the study by Khowaja and Salim (2018). The goal of the developed SG is to help children with ASD identify vocabulary items correctly. After the evaluation process, the participants improved the addressed skills and the improvement was maintained after one and two weeks of the intervention period.

6 | CONCLUSIONS

6.1 | Conclusions

The main goal of this literature review was to study the effects of SGs for people with intellectual disabilities and people with autism. The results indicated that SGs for people with ID and people with ASD could improve practical, conceptual, cognitive, and social skills. Thus, developing SGs for people with ID and people with ASD could be used to enhance the learning process. However, the existing studies for people with ID do not cover entirely the skills of adaptive behaviour or intellectual functioning skills that are presented according to the AAIDD. There is no study regarding the effectiveness of a SG for people with ID addressing social skills. Also, the practical skills of safety, use of telephone, and following schedules and routines are not presented. Therefore, there is a room in the field of designing successful SGs in many adaptive behaviour and intellectual functioning skills. Furthermore, 17 SGs for people with ASD are addressing social skills, rather than other adaptive behaviour skills, because people with ASD have significant limitations in social and communicational skills. As a result, there are limited SGs that address the conceptual skills of understanding money and time and practical skills addressing schedules or routines, use of telephone, and work-related skills. Moreover, researchers develop SGs for people with ID that are either students or young adults. In contrast, most studies regarding SGs for people with ASD target mainly children with autism. Furthermore, even though the design methodology is presented in a limited number of studies, it is observed that involving end users or professionals in the field of special education is preferred, either by using the participatory design method or a similar user- or learner-centred approach.

As far as the evaluation is concerned, it is concluded that most of the studies have been used in a non-formal context (33), where the intervention is executed in extracurriculum activities. However, there are studies that SGs were included in a formal learning process of special education institutions (17). In addition, 30 out of 54 studies regarding SGs for people with ID and ASD use the pretesting–posttesting method to evaluate the effectiveness of a SG. This testing method is preferred in order to quantify the difference in performance on the skills that the SGs are addressing. Also, the sample size in the evaluation of several SGs was rather small, and this poses a limitation in generalizing their results. Moreover, adults with ID are mainly participating in the evaluation process of SGs. On the other hand, the average age of participants in studies for people with ASD is significantly lower, because they address mainly children and students. Lastly, using PCs is the prevailing digital device to host SGs, because it is the most familiar device for the target audience but also for the researchers.

6.2 | Limitations

The literature review presented has some limitations that should be stressed. First, the review is not exhaustive, because certain digital

research databases were not possible to be accessed, such as *IGI Global*. Consequently, some studies could not be obtained and analysed. Furthermore, there were studies that the number of participants in the intervention process was limited; therefore, the effectiveness of these studies could not be generalized.

6.3 | Future work

The systematic literature review presented in this article has shed light on the various skills addressed by existing SGs for people with ID or ASD, their effects, the hosting platforms, and the methods used for designing and evaluating the effectiveness of such games. Although a lot of work has been done in the field, several things have to be accomplished both in devising SGs for covering adaptive behaviour and intellectual skills currently not supported and in thoroughly assessing the effects of such games in educating people with ID or ASD.

ORCID

Stavros Tsikinas http://orcid.org/0000-0003-4959-1756
Stelios Xinogalos http://orcid.org/0000-0002-9148-7779

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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