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A Qualitative Meta-Analysis on the Use of Serious Games to Support Learners with Intellectual and Developmental Disabilities: What We Know, What We Need to Know and What We can Do

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ABSTRACT

This paper provides a qualitative meta-analysis of the literature on the use of serious games to assist learners with intellectual and developmental disabilities. It aims to identify the research trends and the possible directions for future research. The study begins with a preliminary online search and selection of a sample of articles to identify the main categories of disabilities. This is followed by a detailed analysis of a selection of articles chosen on the basis of their relevance, year of publication and representation of the studies carried out in this field. The preliminary analysis of articles published in recent years showed that the majority of the articles dealt with the use of digital games to support learners with intellectual disabilities. The findings revealed reports of participants' higher engagement levels and motivation when learning with serious games, in addition to improved competence or performance in domains of language learning and numeracy. Nevertheless, most researchers acknowledged the need for more rigour in validating the effectiveness of the new games as learning tools.

Introduction

A recent report suggests that video games have a wide and diverse audience, with the average player having been 'gaming' for about 10 years, and youths between 8 to 18 years spending between 33 to 65 minutes of play time per day (Giunti et al., 2015). Whereas many people play games for entertainment and enjoyment, there is an emerging interest amongst game designers and developers to explore the use of digital games for the purpose of improving life in the 'real' world, particularly in domains such as education, sports and more recently healthcare.

The potential use of digital games as learning tools has been investigated for over two decades (Ke, 2009), with findings that have generally been positive. Earlier studies conducted in the late nineties

gave conflicting results – whereas Dempsey et al. (1996) found positive effects of games on intellectual skills and attitudes, Emes (1997) found no significant correlations between the use of computer games and academic performance. However, Vogel et al. (2006), in their meta-analysis of 32 studies, obtained positive effect sizes for learner attitude and cognition when comparing learning from computer games and interactive simulations with traditional methods of instruction. Ke (2009), who carried out a qualitative meta-analysis of computer games as learning tools, revealed that computer games can serve an instructional purpose in multiple educational milieus, ranging from informal settings to community and school contexts.

Although there is ample research and literature on the use of digital games in mainstream education, exploration into the application of these tools in the domain of learners with disabilities is a relatively recent endeavour. A recent meta-analysis conducted by Perelmutter et al (2017) reviewed assistive technology interventions for adolescents and adults with learning disabilities, while Ern (2014) surveyed the literature on the use of digital games as therapeutic interventions for children with autism. In the extant studies, the focus was either on digital games and technologies, or learners with specific disabilities, or on the effects of the games on the learners. The current study attempts to give a comprehensive overview of the impact of digital games on a wider range of learners with disabilities, using an approach adapted from previous reviews on the use of computer-assisted instructions for students with special needs. Two such studies (Fitzgerald et al., 2008; Pennington, 2010) surveyed literature spanning over a ten-year duration, whereas a more recent article by Liu et al. (2013) reviewed research over a five-year period. Whereas Fitzgerald et al. (2008) analysed their findings in terms of teaching methodologies, changes, reforms and inclusion, Pennington's (2010) review was on the design and effectiveness of computer-assisted instruction, and the methodology used in the studies. In addition to identifying the types of learning technologies used and the groups of people with disabilities investigated, Liu et al. (2013) focused on the major research aims, methodologies and outcomes in the studies reviewed.

Likewise, the current research, while focusing on the use of serious games with learners with disabilities, addresses the following questions:

1) What are the main categories of people with intellectual and developmental disabilities for whom serious games have been designed/developed?
2) What are the major aims of the studies on serious games for learners with disabilities over the past 10 years?
3) What are the research methodologies used, outcomes and recommendations arising from these studies?

Together, the answers to these three questions would give an overview of the impact of the use of digital games on learners with disabilities.

Background

Digital games

Rowe (1992, p. 478) defined a game as 'an abstract object which is designed to have no instrumental value; the realization or pursuit of which is intended to be of absorbing interest to participants or spectators'. However, contrary to having 'no instrumental value', games do serve a variety of objectives which can be translated into outcomes, whether directly or indirectly. More recently, authors such as Caillois (2001) brought up the notion of *ludus* which describes a 'game' as the more structured, rule-governed and competitive aspect of 'play', as distinct from *paidia*, the free-flow, spontaneous, improvisational and pleasurable form of play, akin to Rowe's description. Unlike the older models, which perceived games as having no instrumental value, later definitions, such as Juul's classic model (Juul, 2005), defined a game as a rule-guided system, whereby the players value and exert effort in determining outcomes that are variable and quantifiable, with the consequences of the activity being optional and negotiable. As such, this paper adopts the definition of a game as a contest powered by mental and/or

physical strength, whereby the player acts within a framework or set of rules with the purpose of attaining a goal or fulfilling an objective (Giunti et al., 2015; Hogle, 1996; Ke, 2009).

Over the years, games that are played on or mediated by a digital device have been given several terminologies, namely , 'video games', 'computer games' and more commonly 'digital games'. As of late, the term 'serious game' has been added to the vocabulary, to denote the genre of digital games used for instructional purposes. Fleming et al. (2014, p. 229) viewed serious games as 'interventions which are games or utilise elements of gaming as an integral and primary method for achieving their purpose'. Whyte et al. (2014, p. 3821) described this purpose as 'to foster learning of targeted skills' with the intent that 'the learning in the game generalizes to improve real life outcomes', unlike entertainment games which are designed for the sole purpose of leisure. Whereas Susi et al. (2007) claimed that there is no single definition of the concept, this study synergizes previous views to present a more holistic view of serious games as designed with the specific purpose of improving the player's circumstances, be it in terms of his/her learning, well-being or attitude, while offering an enjoyable and immersive experience.

Learners with disabilities

The definition of what constitutes a 'learner with disabilities' and a 'disability' is controversial, with the terminology used varying with researchers and contexts (Torrente et al., 2014). The World Health Organization (n. d.) defines 'disabilities' as 'an umbrella term, covering impairments, activity limitations, and participation restrictions'. In the traditional, medical model, a 'disability' is defined as any form of impairment or limitation in the normal functioning of an individual, whereby 'impairment' implies a reduction or weakening of normal functioning, and 'limitation' implies a curb to normal activity. However, this model has been critiqued for its overemphasis on the causes of the impairment, and hence its tendency to be discriminatory and alienating. Following a publication by the Union of the Physically Impaired Against Segregation (UPIAS, 1976), Oliver (1983) introduced a social model of disability to

advance the UPIAS statement claiming that ‘it is society that disables physically impaired people’ (UPIAS, 1976, p.4), and that disability is a condition imposed on individuals with impairment rather than a condition that arises from the impairment. The aim of the social model was to remove societal and environmental barriers that would impede disabled people from leading an inclusive and emancipated life, as demonstrated in attempts to improve game accessibility to learners with disabilities (Coutinho et al., 2011; Hersh & Leporini, 2012; Yuan et al., 2011). However, thirty years later, Oliver (2013, pp.1024-1026) lamented that ‘despite the impact this model has had, all we now seem to do is talk about it’. Perhaps the way to get beyond just talk is to ‘reconsider the scope of the social model and its relationship with other models of disability’ as proposed by Levitt (2017, pp. 589). This implies identifying the commonalities between the models and using their strengths to work towards benefitting disabled people. In recent years, researchers in disability and special needs studies have witnessed the emergence of yet another school of thought advocating the concept of neurodiversity. Whereas the medical model upholds normalization through the reduction of symptoms and elimination of the causes of impairments and disabilities (Baker, 2011), the neurodiversity movement subscribes to a version of the social model that views impairment as a biological condition arising from a natural variation in neurological development. Hence the proponents of the neurodiversity model consider atypical development as part and parcel of the natural variation within the human population (Jaarsma & Welin, 2012; Kapp et al., 2013)

The current study adopts a nuanced stance with regards to models of disability, and in so doing, acknowledges the strengths and shortfalls of both the medical and social models. As such, in the ensuing sections, developmental disabilities are defined as neurodiverse conditions, in the style of the medical model, to give a clear view of the impairments experienced by the disabled persons, but with the aim of exploring the use of serious games to create those emancipatory and inclusive opportunities that the social model advocates. Thus, rather than focusing on impairments and the limitations they are thought to

impose, the concern should be on the removal of barriers in the serious games originally designed for non-impaired people.

Qualitative meta-analysis or meta-synthesis

A meta-analysis is conceptually an analytical method, traditionally used in quantitative research, to provide a systematic statistical overview of the results from multiple studies aiming to answer the same questions or having the same outcome measure (Hunter et al., 1982; Park and Gretzel, 2007). The objective is to enable findings to be generalized over a larger population. However, quantitative meta-analyses are not without their limitations – for instance, the approach does not control or correct errors in the design and/or biases in the original studies. Furthermore, since the method relies on published findings, it may be subject to publication bias and present an overstated generalization of the findings, since there is a higher likelihood of studies with positive results being accepted for publication, while negative or non-significant outcomes tend to be sidelined. In addition, since traditional meta-analyses are statistical by nature, they are not appropriate for studies with small samples of participants or those using qualitative methodologies.

This article aims to explore findings on the impact of digital games on learners with disabilities. These studies usually involve small samples and are mostly qualitative in nature. A quantitative meta-analysis is thus inappropriate, although as Park and Gretzel (2007) pointed out, findings from these studies can still be integrated through qualitative means, in a process called qualitative meta-analysis or meta-synthesis, following similar replicable procedures as in the quantitative method, but adopting an interpretive rather than aggregative approach (Paterson et al., 2003).

The current study retains some of the items of the PRISMA Statement (Moher et al., 2009), and adopts a qualitative meta-analytic method, derived from the processes used by Park and Gretzel (2007) and Ke (2009). These researchers began by conducting searches through online databases to identify relevant studies in their respective domains. They then classified the papers into pre-determined

categories such as title, dependent variables, participant sample, and nature of research. In Park and Gretzel's study, the data analysis involved extracting and coding dimensions/factors from the text, followed by sorting and resorting the codes, amalgamating similar codes and expanding others to form subcategories upon detailed analysis of the data. In Ke's analysis, the articles were classified on the basis of their research focus. The author also used an open-ended coding matrix to describe the selected papers in terms of codes such as 'purpose, method, intervention, learner, sample size' amongst others (Ke, 2009, pp. 6-7).

The current meta-synthesis involves a systematic review of studies on the use of serious games for people with intellectual and developmental disabilities, with the aim to synthesize the findings, as well as the objectives, methodologies, outcomes and recommendations from these studies.

Methodology

The qualitative meta-analytic approach used in this study combines elements of the PRISMA Statement with the methods used by Park and Gretzel (2007), Hossler and Scalese-Love (1989) and Ke (2009).

Data collection

To identify relevant research in the fields of digital games and learners with disabilities, the literature search was carried out in two phases using academic online databases such as Google Scholar, EBSCOhost, PsycINFO, ProQuest and ERIC.

Phase 1

This involved a preliminary search aimed at identifying the people with the main types of disabilities for whom research on serious games was conducted in recent years. The purpose was to identify the main areas of interest that currently prevail in this domain, in order to inform present and future research. The following criteria were used:

- Year of publication: 2016 and 2017. The search period was limited to these two years to enable identification of the areas of current relevance and for framing future developments.
- Content relevance: general terms were used for the search words to broaden the scope of the literature. These included combinations of key words such as 'digital games' and 'disabled learner', 'learner with disabilities'.
- Database: Google scholar. This search engine was used in the preliminary phase as it is the repository for a wider range of publications than those found in other databases. The objective was to identify the major areas of research interest in a wide variety of print and non-print resources such as peer-reviewed academic journal articles, book chapters, conference proceedings, unpublished theses and dissertations, and technical reports.

A sample of the articles identified from the preliminary search was analysed to identify the main categories/themes, as well as their extent of occurrence. For instance, the preliminary analysis showed that most articles (68%) dealt with the use of digital games to support learners with intellectual and developmental disabilities.

Phase 2

This phase involved a more systematic and thorough search based on the sub-categories within the domain of intellectual and/or developmental disabilities identified in Phase 1. The purpose of Phase 2 is to enable a more detailed review and analysis of studies to date, in order to identify possible trends and directions in research.

The VOSviewer software was used to generate bibliometric maps with articles, published between 2008 and 2017, on each of the sub-categories of intellectual and developmental disabilities identified. The purpose was to show the network of keywords used in the articles and the inter-relationships between them

Inclusion & exclusion criteria

The second search was based primarily on content relevance to each of the sub-categories and was conducted with databases such as EBSCOhost, PsycINFO, ProQuest and ERIC, in addition to Google Scholar. The sample of articles were chosen on the basis of their relevance and year of publication, using 'digital games' and 'serious games' as search words, as well as the types of people with disabilities identified in Phase 1 (such as dyslexia, autism, ADHD, etc.). For the search to be comprehensive, studies with participants of all age groups were included, as well as articles published in print or online, conference proceedings and doctoral and master's theses. The exclusion criteria are included in Figure 1.

The selection was restricted to articles published within the last 10 years (2008 - 2017). Each search was carried out to identify relevant publications over two-year periods for a given disability/impairment type. Thus, for people with each type of impairment (e.g. autistic people), the literature for the entire 10-year period (2008 to 2017) was studied, but the analysis was conducted for five 2-year periods (e.g. articles published in 2008 and 2009 on serious games). This sub-division into 2-year periods was to identify commonalities within the 2 years, as well as the trends across the 10 years. In Phase 2, a total of 103 articles were first identified that were of relevance to the people with the main types of disabilities identified in Phase 1. These articles were further analysed and coded to identify additional themes and subthemes and any interrelationships between them, as well as to allow description of the findings. Following this stage, five representative articles were selected from each of the disability types. To ensure representativeness in terms of relevance, appropriateness and quality, the selection was based on the following criteria:

(a) the digital game(s) was/were used for educational or learning purposes (to ensure that the representative articles were of relevance to serious games),

(b) the papers captured the general research trend of their publication period (to ensure that the articles were in alignment with the main research foci identified in Phase 1, e.g. to improve reading skills of dyslexic learners),

(c) the research purpose, methodology and outcomes/findings (if relevant) were clearly described (to ensure that the representative articles were of acceptable standard and sufficiently detailed) . Figure 1 shows the flow chart for the procedure adopted for paper selection in Phase 2.

Data Analysis

Coding

The articles in the main categories were further analysed and coded to identify additional themes and subthemes and any interrelationships between them, as well as to allow description of the findings. The coding process adopted a semi-structured approach, whereby an initial codification matrix was developed with pre-determined codes such as purpose of study, research design, participants, sample size, methodology, intervention (if applicable), factor being investigated, game information, analysis and findings, implications, gaps and recommendations. The content of the articles was analyzed for emergent dimensions/factors, based on categories surfaced from a preliminary analysis of a subset of the chosen articles. The codification matrix (Figure 2) also allowed for the insertion of in-vivo codes arising from the data as it is being analysed.

Upon completion of the coding process, similar or redundant codes are grouped together to form a comfortable number of salient categories, each describing and discussing a main idea. Thus, 10 categories were identified: purpose of study, type of study, methodology, participants, game information, learning task, duration of intervention, analysis, findings and limitations/recommendations (see Table 2). These were further condensed to four main categories (aims, methodology, outcomes, and recommendations) to frame answers to the research questions. The detailed analysis of the five representative articles for each of the disability categories is shown in Table 3.

Results

Phase 1

The search in Phase 1 identified articles that were sorted out into three broad themes: people with intellectual and developmental disabilities, physical/mobility disabilities, and sensory disabilities. Except for people with physical disabilities, all other broad themes comprised of two or more categories (see Figure 3).

What we know is that between 2016 and 2017, a total of 25 published studies were deemed relevant to the use of digital games in assisting learners with disabilities. Of these, the majority (68%) were on people with intellectual and/or developmental disabilities, 20 % were on those with sensory disabilities and the remaining 12% were on those with physical/mobility disabilities. Since only 32% of the studies identified were on sensory and physical/mobility disabilities, Phase 2 of this study focused solely on the application of serious games for learners with intellectual and/or developmental disabilities.

Phase 2

In Phase 2, the search was expanded to studies conducted since 2008, within each of the intellectual and/or developmental disability types identified in Phase 1. A total of 103 relevant studies were identified. The percentage distribution of studies in each disability/impairment type is given in Table 1.

The network view of the bibliometric map (Figure 4) shows multiple interlinks between key terms used in publications that fall under three main clusters, suggesting that publications tend to focus on ASD, dyslexia and ADHD. The density view (Figure 5) shows the highest concentration of publications on the use of serious games in relation to dyslexia.

People with general intellectual disabilities

From 2008 to 2017, a total of 29 articles dealt with serious games for learners with general intellectual impairments. Figure 6 shows the categories of research aims identified for this domain and the distribution of studies in each category over time. Five main research aims were identified: (i) to improve

behavioural outcomes, (ii) to improve affective/emotional outcomes, (iii) to improve intellectual outcomes, (iv) to provide a review of the literature, (v) to propose designs/models for serious games. The highest number of publications were on the proposal of design models for serious games and reviews of the literature. However, in recent years, these studies seem to have taken a downward trend, amidst a surge in the number of articles on motivation, engagement and behavioural outcomes.

The analysis of five representative articles indicated that, in the early days of digital gaming (2008 and2009), published articles focused on the outcomes of game play, such as the relationships between video games and intellectual processes, motivation and desirable behaviour (Gamberini et al., 2008). The later periods (2010 – 2015) showed a proliferation of articles exploring game designs to cater to users' needs (Tomé et al., 2014), and for greater accessibility to people with disabilities, in line with the social model of disability, thus giving an indication of *what we need to know*. While some researchers developed new games, others indicated what could be done in their recommendation of the use of games available in the market, and the customization of the existing digital games to the needs of the learners with disabilities (Yuan et al., 2011). In recent years (2016 and 2017), articles reported outcomes of empirical studies (Chuang et al., 2016; Chuang et al., 2017; Main et al., 2016; Mangowal et al., 2017) while others were proposals for future research (e. g. Freina et al., 2014). These studies revealed that both students and teachers held positive views regarding the use of serious games as an alternative mode of instruction. There were also reports of improved learner motivation and engagement, and in some instances, improved performance.

Dyslexia

This is a reading disability whereby the learner experiences literacy-based learning difficulties (Gooch et al., 2016), namely in acquiring "efficient reading skills despite conventional instruction, adequate intelligence, and sociocultural opportunity" (Demonet et al., 2004, p. 1451). Dyslexic learners struggle with reading tasks and tend to have low self-esteem and motivation in language learning. In recent years,

the use of serious games to promote language learning has had a measure of success in motivating learners with dyslexia. Serious games thus offer an alternative platform for language learning and acquisition for dyslexic learners.

The search conducted in this study identified 21 articles, published between 2008 and 2017, that are directly related to the use of digital games to support dyslexic learners. Of these, about 28.6 % were on the use of serious games for prediction or early detection of dyslexia in young learners (e.g. Geurts et al., 2012). A 47.6 % dealt with the use of games to improve reading skills and motivation in language learning, while 23.8% were on game design and development. In 2008 and 2009, the articles focused on game development and the use of serious games for the improvement of language learning. However, in recent years (2016-2017), whereas the publication rate for articles on game development has been maintained, those on language learning have been superseded by studies on the use of serious games for prediction and early detection of dyslexia (Figure 7).

The analysis of five representative articles on serious games for people with dyslexia showed that, whereas earlier publications tended to report on research proposals, game design, guidelines and development (Lyytinen et al., 2009; Smythe & Giuliyi, 2010), most of the studies in recent years described prototypes of new games (e. g. DIESELX, Prosodiya, Words Matter, Dytective, DysMusic) that were tested for their suitability in assisting learning or in predicting the occurrence of dyslexia (Gaggi et al., 2017; Rello et al., 2014; Ward et al., 2012;). All studies identified in the search engaged children as participants, with some of them as young as preschool stage. While the participating children generally enjoyed the games, future work, hence *what we need to know and what we can do*, should involve refinement and validation of the new games as tools for various purposes such as early detection.

Attention Deficit Hyperactive Disorder (ADHD)

This is a neurodevelopmental impairment characterized by inattention, hyperactivity, impulsivity and difficulty in exerting self-control. Children with ADHD often encounter difficulties in controlling their

behaviour, making it hard for them to integrate socially and hampering their performance in school. In recent years, serious games have proven to be effective in catering to the needs of learners with ADHD, by improving visual memory, attention span, processing speed and intellectual control (Cromley, 2006; de la Guia et al., 2015). The search in this study identified 11 articles, published between 2008 and 2017, that are directly related to the use of games in assisting learners with ADHD. Figure 8 shows the research focus on such articles.

What we know is that, of these, about 27 % were on the use of serious games to enhance motivation and self-perception of competence. Fifty-five percent dealt with the use of games to improve intellectual functions and skills, 9% were on guidelines for game design and development and another 9% dealt with the negative effects of addictive gaming on ADHD. Prior to 2013, there were fewer than 5 articles on the use of digital games to assist people with ADHD. The bulk of the articles were published after 2013 and most of them were on either the development of intellectual functioning and skills or learner behaviour, motivation and self-efficacy. As in the case of dyslexia, these studies focused mainly on children and youths. Except for the literature review articles by Papanastasio et al. (2017) and Weinstein and Weizman (2012), most papers were on the introduction of new games to assist individuals with ADHD in coping with their disability.

The analysis of five representative articles on ADHD showed that serious games were able to improve the ADHD participants' motivation, self-efficacy, attention, memory and prosocial skills. Whereas earlier research cautioned against the dangers of game addiction (Weinstein & Weizman, 2012) and identified guidelines for game design (McKnight, 2010), most recent studies adopted an experimental approach to explore the use of digital games in improving executive functions such as memory and attention (de la Guía et al., 2015), as well as ADHD learners' motivation and self-efficacy (Andersen & Sorensen, 2017; Retalis et al., 2014), highlighting *what needs further investigation and action*.

Autism Spectrum Disorder (ASD)

Autism Spectrum Disorder (ASD) is ‘a group of developmental disorders’ that include ‘a wide range of symptoms, skills and levels of disability’, that may involve difficulty in communicating and interacting socially, repetitive behaviours, limited interests or activities (National Institute of Mental Health, n. d.). While this medical definition seems to focus solely on the symptoms displayed by people with autism, the neurodiversity model proposes ASD as a positive neuro-variation in individuals who should be provided with the appropriate assistance and provision of rights, recognition and acceptance (Cascio, 2012; Jaarsma & Welin, 2012).

In the current research, 35 articles on the effect of serious games on people with ASD were identified for the search period spanning from 2008 to 2017. Few articles were published prior to 2010. Figure 9 shows research focus for articles on serious games for people with ASD.

What we know is that in subsequent years, the ensuing publications reported on instructional support towards development in behaviour (37%), cognition (6%) and affect (17%) in individuals with ASD. Twelve percent of the papers reported on game design and development, and 14% on reviews of the literature. There were a total of five papers (14%) that dealt with other issues such as guidelines for game design and the association between game play and autism. Over the years, studies focused on the use of serious games to improve behaviour and affect in ASD learners (Harrold et al., 2012; Van Veen et al., 2009). Although there were a few recent publications on other domains such as intellectual and affective development (Jung & Sainato, 2015; Whyte et al., 2014), there was a decline in research on digital game and ASD and the interest in such studies seems to have waned over the years. *What we need to know* are the reasons for this decline in interest and *what we can do* is for future research to explore the current needs of learners with ASD and to introduce games that enable these needs to be met.

The analysis of five articles representative of the research on serious games for people with ASD showed a clear inclination towards the development and provision of therapy for individuals affected by ASD, or in the least, towards providing them with support (Gillespie et al., 2017; Harrold et al., 2012;

Jung and Sainato, 2015; Van Veen et al., 2009). These studies revealed positive outcomes and improvements in interaction, affect, as well as social and intellectual skills. The review conducted by Zakari et al. (2014) on 40 serious games designed for children with ASD suggested the need to develop more games to capture the progress and development of skills. One of the issues arising from these findings was the game design focus to be on therapy rather than education and improvement of academic performance. Possibly, the reason may lie in the perception that the main challenge faced by autistic people is social rather than academic in nature. In fact, according to the American Psychiatric Association (APA, 2013), the dominant feature of ASD is an impairment in the social domain, ranging from mild to severe and occurring at all levels of intelligence. The belief therefore, is that there are many autistic people who are of typical, if not superior intelligence and academic ability, but their social challenges may affect and undermine their academic performance (Shmulsky et al., 2015), hence the need to address their social difficulties first and foremost.

The research on the use of serious games for people with ASD was limited by the small participant sample size. This indicates that future work could focus on validating the tools and approaches used, assessing the reliability of the prototype study outcomes and investigating whether the effectiveness of the games is transferable to other contexts and other types of autism within the spectrum.

Dyscalculia

Dyscalculia is defined as a 'condition that affects the ability to acquire arithmetical skills' (Butterworth, 2011, p. 251). Chodura et al. (2015, p.129) further explained that it is a 'specific impairment of mathematical abilities…diagnosed by low achievement on a standardized mathematical test', and not caused by 'low intelligence, inadequate schooling, sensory deficits or other neurological, psychiatric or medical disorders'. Individuals with dyscalculia have a poor understanding of simple numerical concepts and have difficulties learning facts and processes related to numbers. The current study identified only

eight articles (one of which involved a meta-analysis) related to dyscalculia and serious games throughout the last 10 years. Figure 10 shows research focus for articles on serious games for people with dyscalculia. Seventy-five percent of the articles were on the development and use of games for remediation and for improving intellectual functions and numeracy, with 25% on review and evaluation of extant research on this field. The five representative articles reported studies aiming to improve numeracy (de Castro et al., 2014; Käser et al., 2013; Laurillard & Baajour, 2009) intellectual function (Cos, 2015) and motivation (Cezarotto & Battaiola, 2016). *What we need to know* are the perspectives, experiences and needs of the learners with dyscalculia and, armed with this knowledge, *what we can do* is to introduce the appropriate games to improve their learning experiences.

Review of main research aims

The main research aims identified from the 103 relevant studies were to improve behavioural, affective and intellectual outcomes, to provide reviews of the literature, and to propose designs/models/guidelines for digital/serious games. There were also studies with diverse research agendas, such as game accessibility, games as predictive tools and negative influence of excessive gaming. Figure 11 shows the distribution of studies in each of the categories of research aims.

Review of methodologies, outcomes and recommendations

The methodologies used, research outcomes and recommendations for future studies were identified from the 25 representative publications selected for detailed analysis. The distribution of methodologies, outcomes and recommendations is shown in Figures 12, 13 and 14 respectively.

Figure 12 (on methodologies used) reveals that most of the studies adopted an experimental approach, with a sizeable number of review papers and those on game design.

From Figure 13, one can infer that most of the studies reported research outcomes related to learner improvement (e.g. improvement shown by learners in literacy, numeracy, motivation, communication and social interaction), followed by guidelines and recommendations, as well as game designs and prototypes.

Figure 14 shows that most of the recommendations for future research were on game outcomes. These include the development of strategies, interventions, tasks or games that would improve cognitive performance and intellectual processes, as well as the assessment of their effectiveness. There were, in addition, suggestions to develop serious games that are customized to learners with disabilities' needs and circumstances.

Discussion

This study began by asking three main research questions on (i) the nature of the people with the main intellectual and/or developmental disabilities for which serious games have been designed/developed, (ii) the major aims of the studies on serious games for learners with disabilities, and (iii) the research methodologies used, outcomes and recommendations arising from these studies.

In answer to the first research question, the people with the main intellectual and/or developmental disability types for whom serious games have been designed/developed are those with dyslexia, ADHD, autism, general intellectual impairments, and to a lesser extent, dyscalculia. The search for studies conducted in earlier years yielded a significant number for dyslexia and autism. In the past 5 years (2013 – 2017), research interest in the use of serious games for people with general intellectual impairments and dyslexia seems to have been sustained but comparatively, there have been fewer such studies in the domain of autism and ADHD despite the positive outcomes that resulted from these. Furthermore, the games designed for persons with ADHD not only addressed the issues specific to this condition but led to improvements in general intellectual performance. As for dyscalculia, the number of articles generated has been constantly low over the years, perhaps because the condition is not as well known or understood. Given the general interest in improving mathematics performance in schools, there is merit in expanding the use of assistive technologies for dyscalculia, considering the positive outcomes with dyslexia. Game developers and researchers could perhaps focus on games that could benefit people with different impairments in addition to focusing on specific conditions. The differences in serious game research for

people with different disabilities could be attributed to the need to customize the game to the specific needs of the persons with disabilities. This depends on the advances in technology and level of sophistication of the games, hence offering a possible reason for the change in research trend over time.

In answer to the second question, the current research found that the majority of the selected articles aimed at enhancing outcomes in the intellectual domain, such as improving language learning, numeracy, memory, and attention. In addition, a sizeable number of studies targeted at improving behavioural outcomes, as well as task engagement and motivation. Much of the learning from these studies are disability-related and focused on therapy and rehabilitation rather than academic, vocational or leisure-oriented. The review of the literature also identified studies involved in developing predictive games to enable screening for a particular condition, as in the case of early detection of dyslexia (Geurts et al., 2012). Game designers could look into the possibility of developing games that have both diagnostic elements for other forms of disability, enabling early disability assessment and provision of support. Though the focus on early detection of disabilities and on strategies for improvement of intellectual and behavioural outcomes was born out of good intentions, it seems to suggest that disability studies over the past decade had taken on a deficit approach, emphasizing on overcoming or rectifying learner weaknesses rather than developing their existing strengths. It is gratifying to note that in recent years, there was a high percentage of 'design' articles, presenting proposals or guidelines on game design and development. These include papers on a number of 'emerging' fields of study, e.g. those dealing with improving game accessibility to disabled individuals (Coutinho et al., 2011; Hersh & Leporini, 2012; Yuan et al., 2011). These studies support the social model for inclusivity and emancipation, whilst offering a platform for future research. For instance, Yuan and colleagues proposed a number of accessibility strategies that enabled players with impairments to overcome barriers during the stages of interaction in a game. Though it might be plausible to design universally accessible, multiplayer games that users with different types of impairments could play, these researchers cautioned against trade-offs that could remove the fun elements

of a game. This is because the enjoyment derived in gameplay arises from the visual, auditory and haptic stimuli in the digital display. However, designing a game for visually-impaired people will require amplifying and enhancing the quality of auditory inputs, but these will not be accessible to the hearing-impaired people. Likewise, enriching the visual/auditory stimuli to cater to hypo-sensitive autistic learners will be detrimental to those who are hyper-sensitive to sensory inputs. Nevertheless, improving game accessibility would still be a profitable endeavour, given the boost in demand should the games be customised for disabled users. The way forward is to consider the various ways in which gameplay is affected by different impairments and to provide some accommodation for the steps that the people with disabilities are unable to perform so as to enable them to carry on with those that are within their reach.

A comparison of the development and use of games for learners across the different disability categories reveals that the number of articles dealing mainly with reviews, evaluations, guidelines and explorations on the development and design of games was highest (45.7%) for autism spectrum disorder, followed by intellectual disabilities (38.0%), dyscalculia (28.5%), dyscalculia (25%), dyslexia (19%) and ADHD (9%). On the other hand, ADHD had the highest number of studies (54.5%) reporting on the development and use of serious games for improving cognitive functions (such as memory retention) or daily life skills (such as time management and planning). Likewise, for people with other types of disability, there was a sizeable number of publications on the uses of serious games: dyscalculia (62.5% - for improvement of numeracy and maths skills), general intellectual disabilities (41.4% - for diagnosis and academic improvements), dyslexia (38% - language learning and prediction), and autism (31.4% - on life skills such as communication, social interaction and engagement). Furthermore, a number studies reported on the use of serious games for promoting positive dispositions. Thus, 27.2% of articles on ADHD reported on improved motivation, 17.1% of those on autism were on emotional development, 14% of those on dyslexia, 12.5% of those on dyscalculia and 6.8% of those on general intellectual disabilities were on enhanced motivation and enjoyment.

In answer to the third question, the most commonly used methodologies were experimental designs, with a number of publications reporting on reviews of the literature and game design protocols. The majority of the studies reported research outcomes related to learner improvement in diverse areas, e.g. improved literacy, numeracy, motivation, communication and social interaction. Other output included guidelines for games, as well as game designs and prototypes. Although most studies adopted an experimental approach, the authors recognized a number of limitations pertaining to three main areas of their research.

First, limitations arise from the methodologies used in the studies. For instance, most of the research projects were conducted with small numbers of participants, imposing limitations on statistical analysis and thus the generalizability of the findings (Chuang et al., 2016; Ward et al., 2012; Retalis et al., 2014; de la Guia et al., 2015). In addition, the small sample size did not allow for the inclusion of control groups in empirical studies with intervention programs. One exception is a game designed by Lyytinen et al. (2009) for the prevention of dyslexia in children, which was attempted by 50,000 Finnish children. Also, some articles focused on game design but gave insufficient details on data collection and analysis, raising concern over the validity and robustness of the research outcomes. A further limitation was identified with studies in which the interventions took place in the game users' homes rather than in an experimental setting, as in the study conducted by Chuang et al. (2016). In this instance, the intervention involved children with sensory integration dysfunction (SID), a neurological condition in which the brain is unable to accurately process certain types of sensory information. The study also involved the participation of the disabled children's parents and any other adults (or family members) engaging in the therapy with them. Although there might have been processes for recording the attempts at game-play (Käser et al., 2013), there was insufficient monitoring of how frequently or regularly the disabled users carried out the intervention tasks or whether they went through adequate game sessions for the training to have significant impact or effect. Lastly, for people with impairments affecting language or numeracy

skills, such as dyslexia or dyscalculia, the games that were designed and developed usually focused on improvement in one aspect of the skill or capability, e.g. either spelling or reading in a specific language. Hence the games may not be applicable to literacy in other languages or improvement in other language skills (Rello et al., 2014)

Secondly, there were limitations to the attempts to evaluate past research in order to provide guidelines for future ones. Many existing serious games cannot be used by people with cognitive impairments because these games make use of capabilities that some of them lack, such as speed reading, identification of cues, retention and recall of information, manual dexterity, amongst others (Tomé et al., 2014). Most of the guidelines proposed in review papers were not derived from feedback or views obtained from disabled persons, but from general sources of information, some of which may not be scientifically validated, or relevant to the disabilities or impairments in question (McKnight, 2010).

This led to the third and perhaps most salient shortfall in extant research on the use of serious games for disabled persons, which has to do with the issue that few studies attempted to seek users' views and suggestions on the development of games that were to be designed primarily and specifically for them. In evaluating the effectiveness of the serious games, most findings were derived from the researchers' observations of user behaviours and preferences, rather than from direct feedback from the users themselves. There were nevertheless, a few studies that gathered views from either the disabled participants or their caregivers. In the study by Chuang et al. (2016), parents (but not their participating children) were interviewed and surveyed but not all parents who participated in the project responded to the survey. The few studies that did obtain feedback from the disabled participants made use of surveys or self-report questionnaires such as the subjective reading and writing skills questionnaire for participants with dyslexia (Rello et al,. 2014) and the training evaluation questionnaire for dyscalculia (Kaser et al.,, 2013). In addition, the study on early identification of development dyslexia by Gaggi et al. (2017) is one of the few studies that obtained feedback from pre-school users and took into consideration their views

for future game development processes. Likewise, Gillespie et al. (2017) conducted a rare study that obtained participatory feedback from autistic college students and actively sought their involvement in game design and evaluation. Pertaining to the domain of ADHD, de la Guia et al. (2015) collected data from user responses to a number of questions, while Andersen et al. (2017) conducted a comprehensive mixed-method study on games and ADHD, with the participation of 56 focus learners affected by the condition. Qualitative data were collected from both teachers and focus learners on their various experiences. One can infer from these recent studies that, despite a slow start, there is a welcomed trend to include disabled prospective game users in the process of game design, development and evaluation. It is noteworthy that these were disability domains whereby the participants experienced difficulties related to mastery of academic or social skills, and whose intellectual capabilities were not otherwise affected.

Recommendations

Given the limitations outlined earlier, improvements in the methodologies used could include the use of larger samples of participants to avoid the Hawthorne effect, whereby subjects' awareness of their participation in an experiment leads to an alteration of their behavior during the process (Jones, 1992). This poses a threat to the credibility of the research outcomes, which could be improved through controlled experiments and rigorous statistical analysis of the data. Various authors made recommendations for more effort to validate the new games and to go beyond trials and prototypes to establish reliability of the outcomes. It is also noteworthy that most of the recommendations were on developing more serious games to improve learner outcomes, and on customizing games to cater to the diverse needs of the disabled individuals.

With regards to the limitations to game design and development, recommendations were made for greater emphasis on the analysis of effective strategies and the setting up of guidelines for game design, as well as the development of specific game tasks that are aligned with the improvement of specific intellectual processes. Some authors recommended the development and use of more games that promote

enjoyment, engagement and motivation rather than those that merely focus on improving capability or overcoming challenges due to impairments. Hence there were also suggestions for the development of more games that enable learning to be applied to daily life functions such social communication and interactions. This approach incorporates elements of both the social model (whereby the gameplay helps the disabled person to familiarize with actual contexts and possible difficulties and learn to overcome them) as well as the medical model (whereby the disabled person learns to overcome these difficulties through the gameplay).

Last but not least are the recommendations that centred upon the disabled learners. These include more information on effective gaming strategies and on the needs of the respective disabled users, the customization of games to meet users' needs, greater game accessibility to users, exploration of strategies and tasks for improvement of user performance, and opportunities for users to learn at their own pace and to make use of their existing capabilities. The way forward is to have greater user involvement in the formulation of guidelines for game design and development. Market research and customer satisfaction surveys could be administered to assess the preferences of customers with disabilities, and game producers should initiate conversations with their targeted clients, irrespective of the nature of their disabilities.

Limitations of the current study

The current meta-analysis is itself not without limitations. As it relies on published articles, it is not free from publication bias since, as stated earlier, there is a higher tendency for papers with positive outcomes to be accepted for publication. In addition, serious games were used earlier and more pervasively for some types of disabilities than for others. As such, although the selection of articles published within the last decade allowed for the review of recent research, it may have led to the omission of some seminal articles, published in the early days of development of serious games, but which are highly influential in determining the surge of interest in this particular domain. Future research could perhaps extend the

selection of articles to include those published as far back as when the first serious games were produced commercially.

One of the challenges encountered in this study lies in the heterogeneity and broad spectrum of intellectual and development disabilities discussed in the literature, which made selection and categorization of articles problematic at times. ASD, for instance, comprises learners who range from mildly to severely autistic, and dyscalculia is a broad term for persons with developmental impairment of mathematical abilities, but may also include those with mathematical difficulties or those considered to be at-risk dyscalculic (Chodura et al., 2015). The occurrence of comorbidity between various types of disabilities or impairments further complicates matters. As such, the design and production of multiplayer games may resolve the problem, at least partially, in enabling accessibility to users across a wider range of disability types and degree of severity.

Finally, the trustworthiness of the study could be enhanced through the establishment of the credibility (veracity of findings), transferability (applicability of findings to other contexts), confirmability (neutrality in research findings) and dependability (replicability and consistency of findings). This could be achieved through expanding the data search to include a larger pool of articles, and inclusion of member checks and audit trails.

Conclusion

The aim of this study was to provide an overview of the impact of serious games on learners with disabilities. In so doing, the study has identified the current trends in research on the use of digital games to assist learners with intellectual and developmental disabilities in terms of *what we know, what we need to know and what we can do*.

Implications for learners

What we know is that the use of serious games has been explored, with potential impact, for people with dyslexia, dyscalculia, ADHD, autism as well as the general intellectual disabilities. In the domain of

general intellectual disabilities, most of the publications were proposals for serious games catering to users' needs and for greater accessibility to people with disabilities, with a recent trend on motivation, engagement and behavioural outcomes. For learners with ADHD, serious games were effective in enhancing visual memory, attention span, processing speed and intellectual control, in addition to improving learner behaviour, motivation and self-efficacy. With regards to learners with ASD, serious games were found to improve behaviour and affect, while dyslexic learners found serious games fairly effective in promoting language acquisition, improving reading skills and motivation in language learning, as well as in the prediction and early detection of the condition. Likewise, research on serious games with dyscalculic learners focused mainly on the development and use of games for remediation and for improving intellectual functions and numeracy. Generally, we now know that the most common research aims were to create direct impact through enhancing learners' behavioural, affective and intellectual outcomes, as well as indirectly through the provision of reviews of the literature, and the proposal of designs/models/guidelines for the development of digital/serious games.

Implications for research

In terms of *what we need to know and can do* for future, enhanced impact, some authors highlighted limitations and proposed suggestions for future research. These include the need for further validation of the new games to establish the reliability of the outcomes, given that the studies were often conducted with small numbers of participants. More could be done to develop and evaluate games that could support learners with disabilities, remove or reduce barriers they encounter, improve and record their learning outcomes and skills, and promote enjoyment in learning. It has been reported that serious games work better in some contexts than others. For instance, some instructional games promote higher-order thinking (such as strategizing) rather than content knowledge acquisition. Other games are more effective for some types of learners than others, e.g. those with cognitive impairments may benefit more from instruction

gameplay than those with sensory impairments since the latter are unable to reap the benefits of the sensory inputs that are inherent features of digital games. As such, some researchers, such as Ke (2009), proposed that educators and game designers should assess the multiple factors that influence a game-based learning environment and thus make more accurate decisions with regards to how to use instructional games effectively and in what contexts.

Implications for educators

Last but not least, there is the need for adequate instructional support features (such as teachers, facilitators, parents and peers) to assist disabled learners in the process of game play. Instructional games are useful tools for learning but they are not in a position to replace the human figure as the prime agent in facilitating learning. Teachers who are able to leverage technology-based strategies, such as the use of serious games, could offer differentiated learning experiences to students with special needs , hence fostering an inclusive environment in which the latter can learn at their own pace, focusing on their strengths rather than their weaknesses. The use of game-based learning would provide special education teachers with some reprieve from the stress they experience while taking care of their charges (Andersen et al., 2017). In addition, students perceive game-based learning as introducing the 'fun-factor', enjoyment and motivation in learning, while promoting mastery of knowledge and skills.

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Yuan, B., Folmer, E., & Harris, F. C. (2011). Game accessibility: a survey. *Universal Access in the Information Society, 10(*1), 81-100.

Zakari, H. M., Ma, M., & Simmons, D. (2014, October). A review of serious games for children with autism spectrum disorders (ASD). *International Conference on Serious Games Development and Applications*, 93-106. Springer, Cham.

Figure 1. Procedure for paper selection in Phase 2.

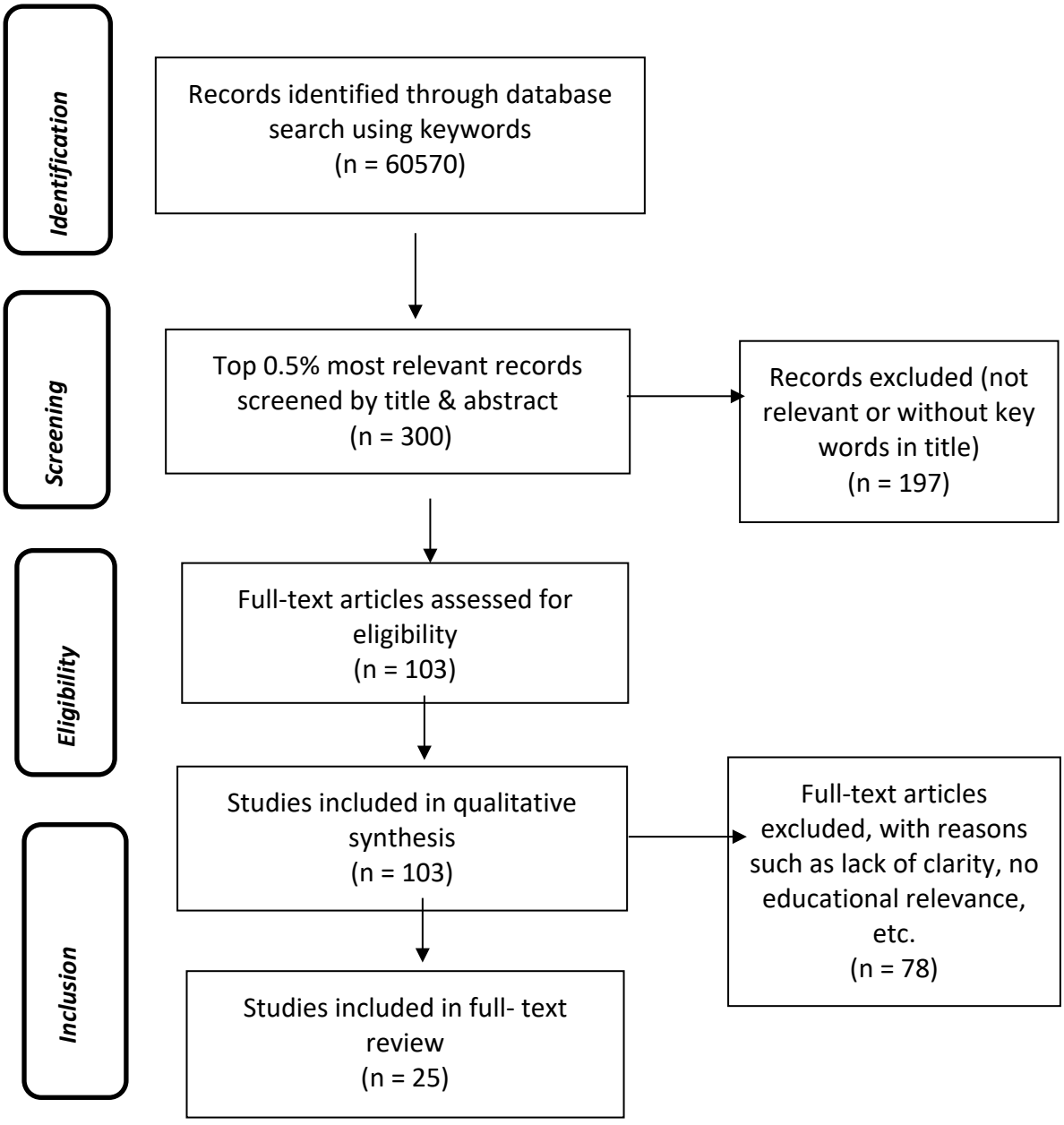

Figure 2. Coding matrix showing the sequential process of open, axial and selective coding

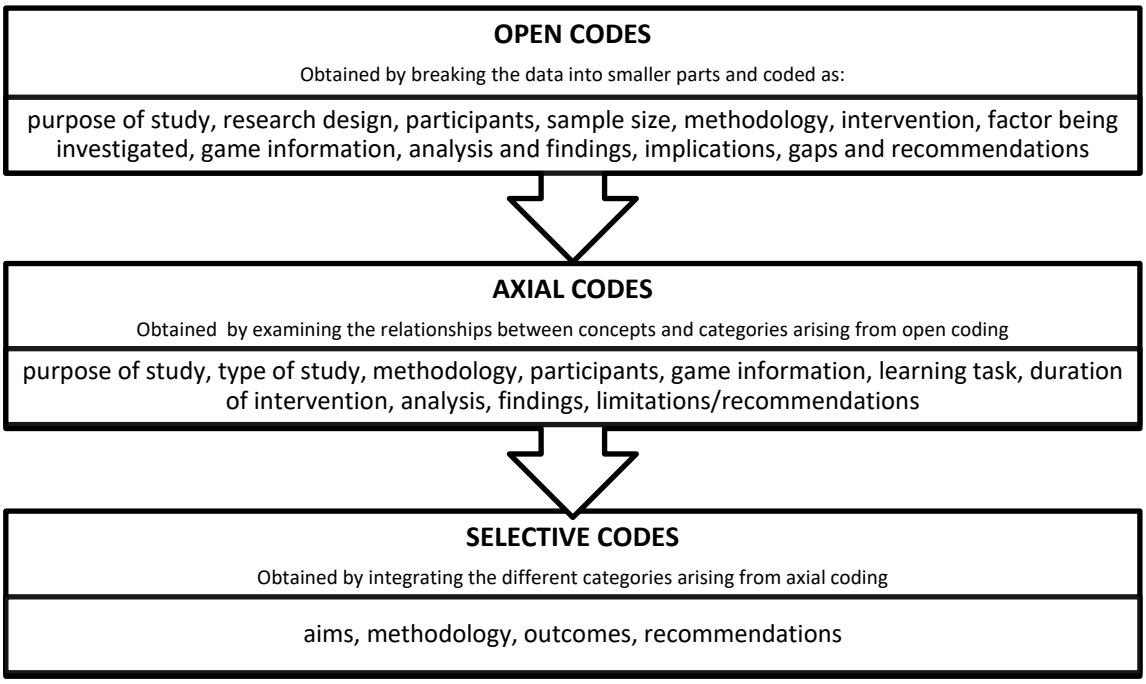

Figure 3. Themes of studies in review and the number of articles in each disability/impairment type.

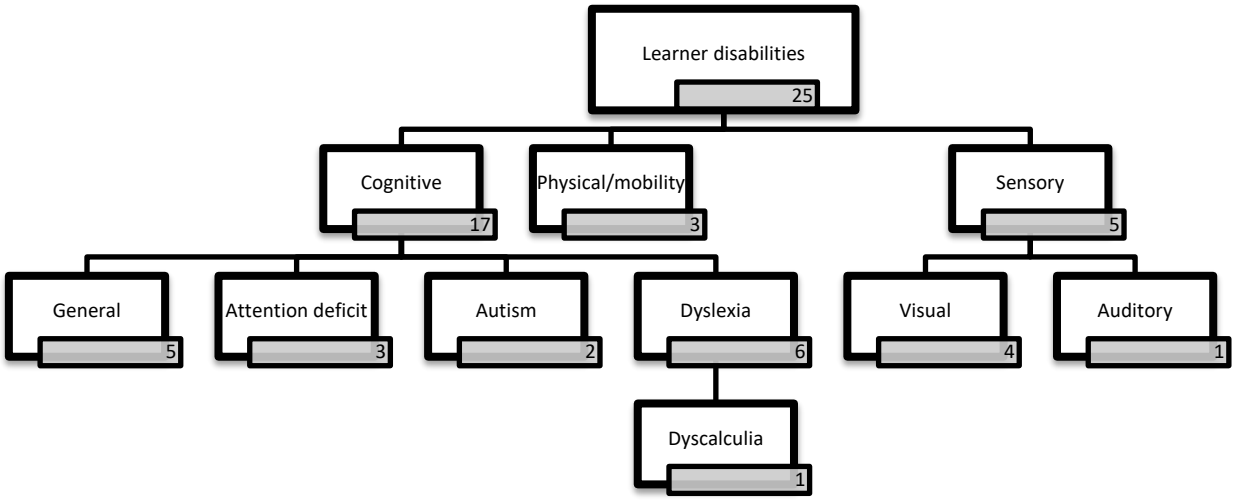

Figure 4. Network view showing publication clusters and links.

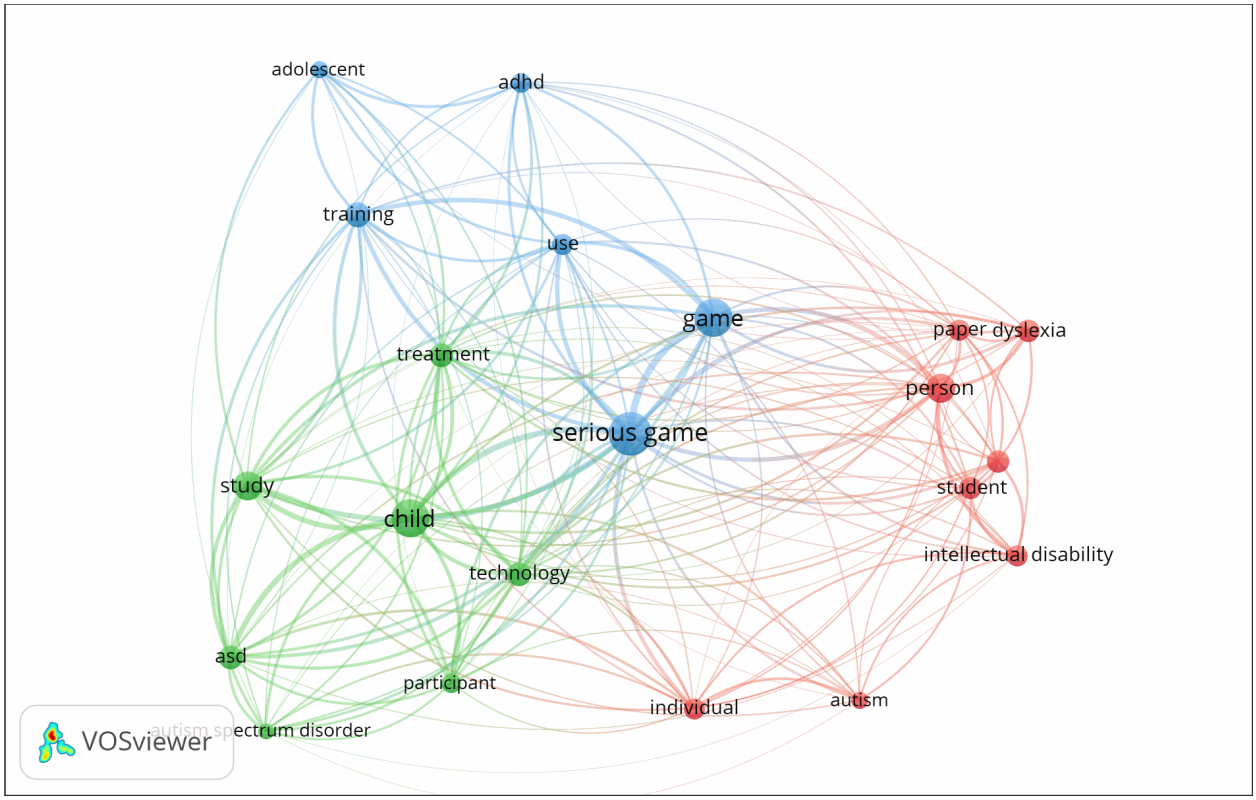

Figure 5. Density view showing the number of publications in each category.

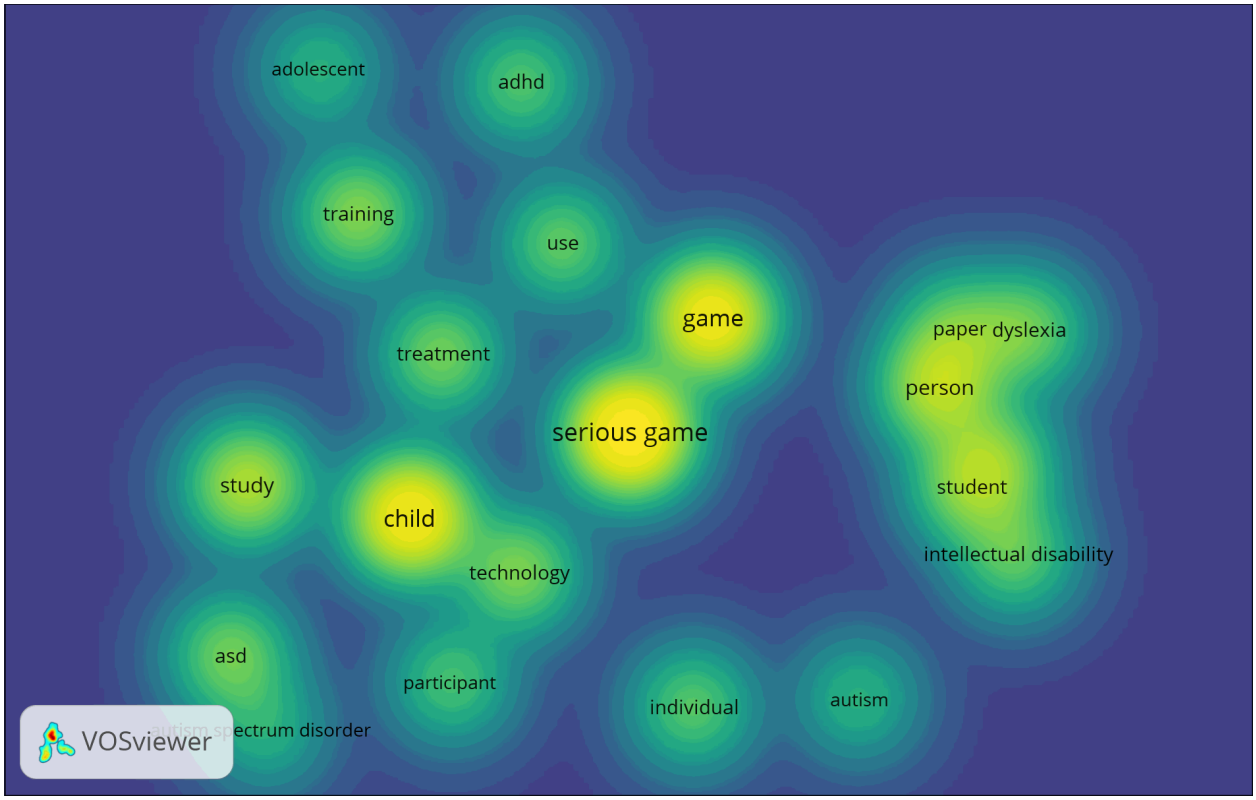

Figure 6. Research aims for articles on serious games for people with general intellectual disabilities.

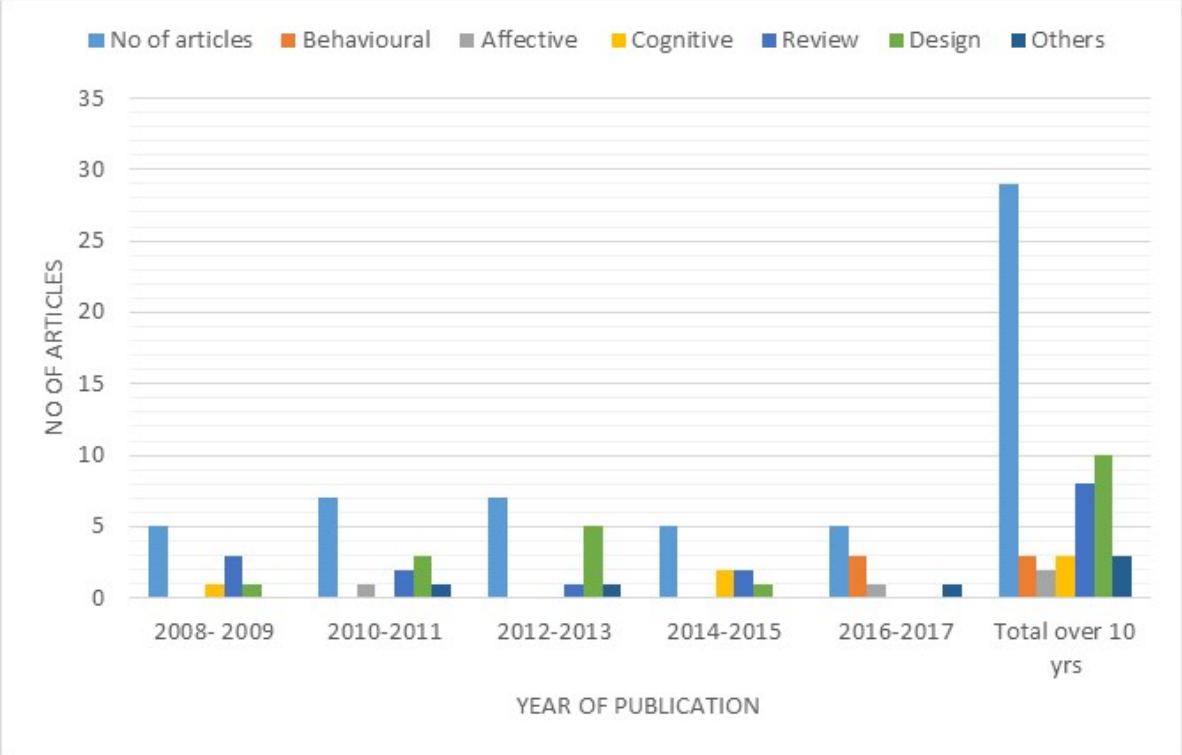

Figure 7. Research aims for articles on serious games for people with dyslexia.

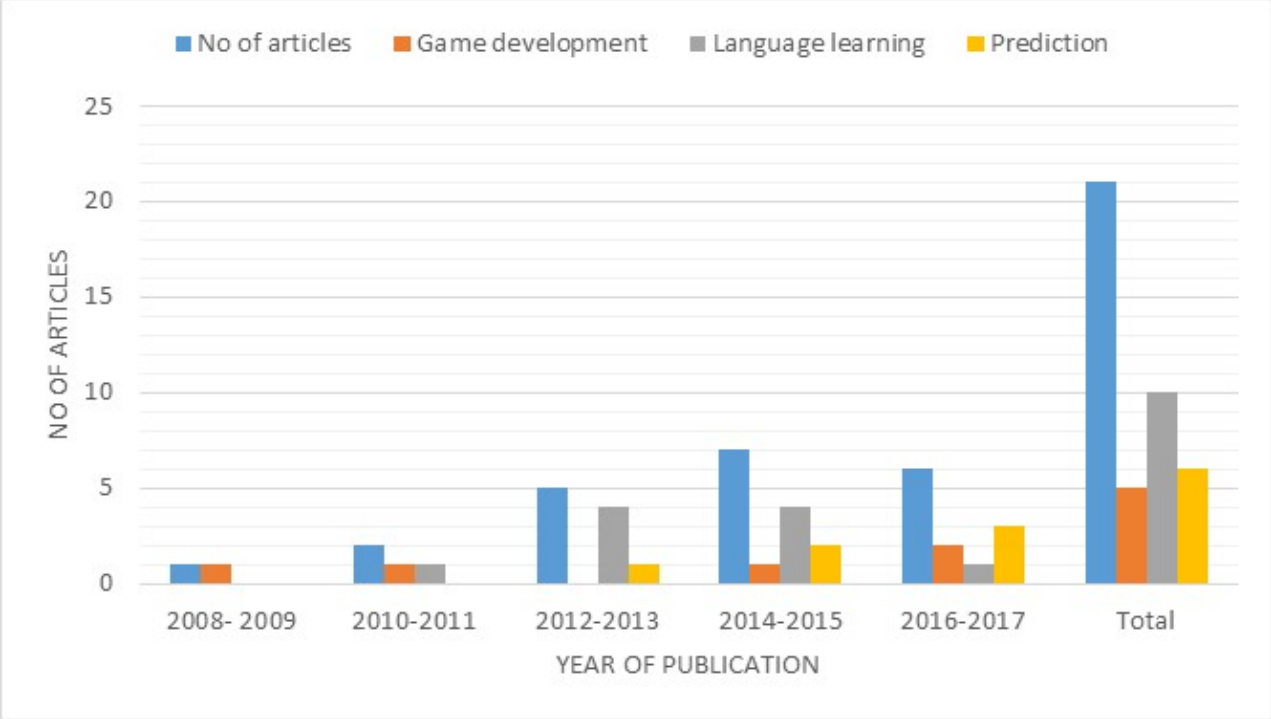
No of articles
Game development
Language learning
Prediction
25
20
15
10
5
0
NO OF ARTICLES
2008- 2009
2010-2011
2012-2013
2014-2015
2016-2017
Total
YEAR OF PUBLICATION

Figure 8. Research aims for articles on serious games for people with ADHD.

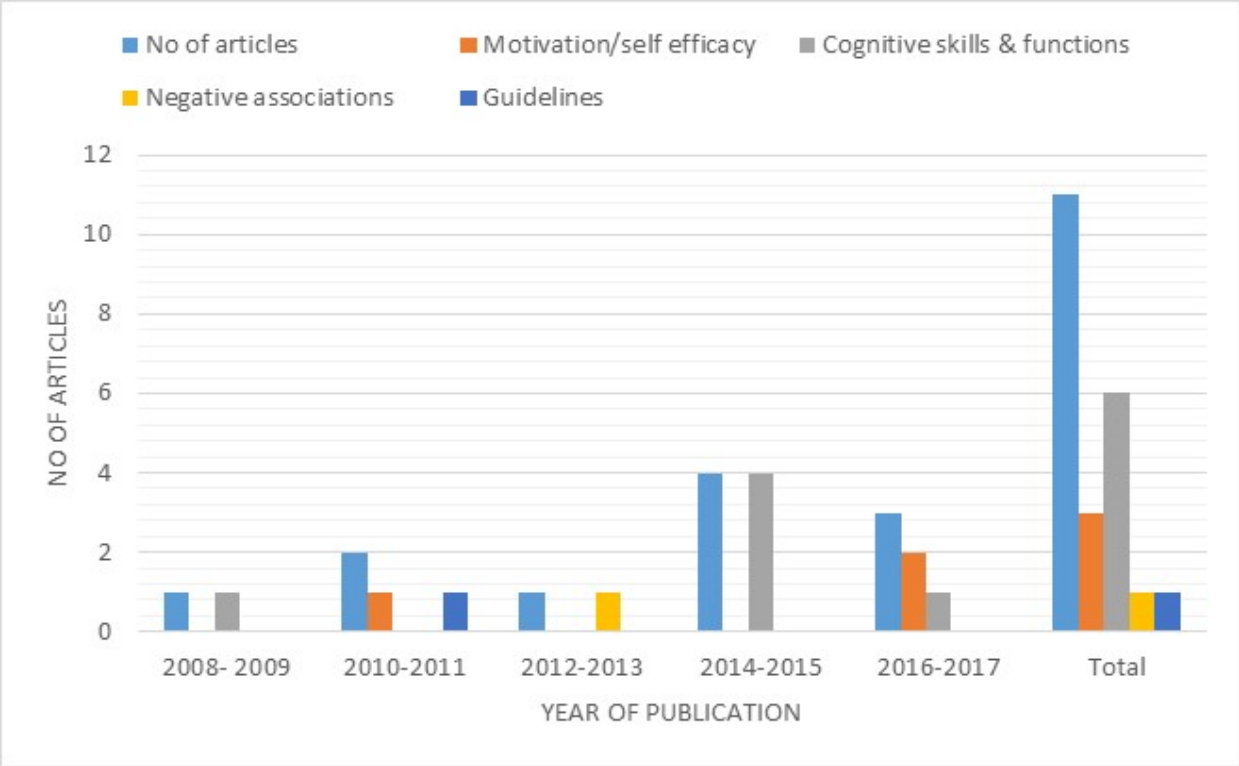

Figure 9. Research aims for studies on serious games for people with ASD.

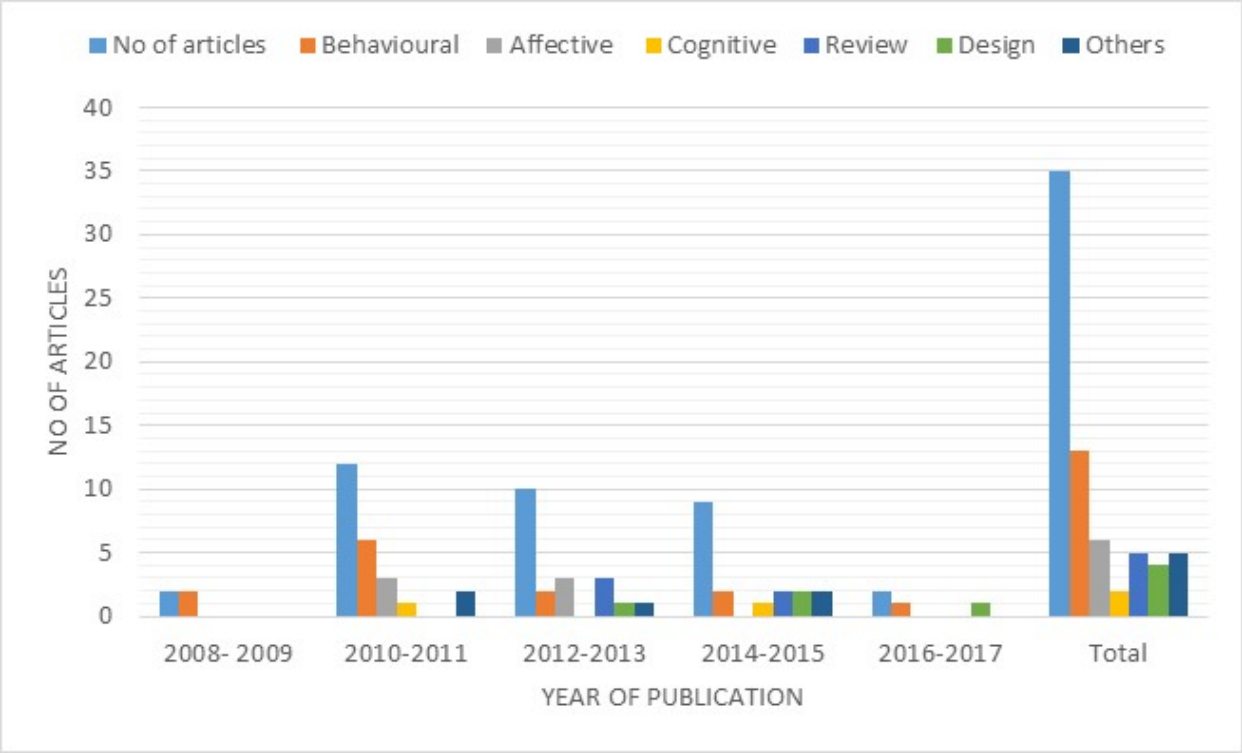

Figure 10. Research aims for studies on serious games for people with dyscalculia.

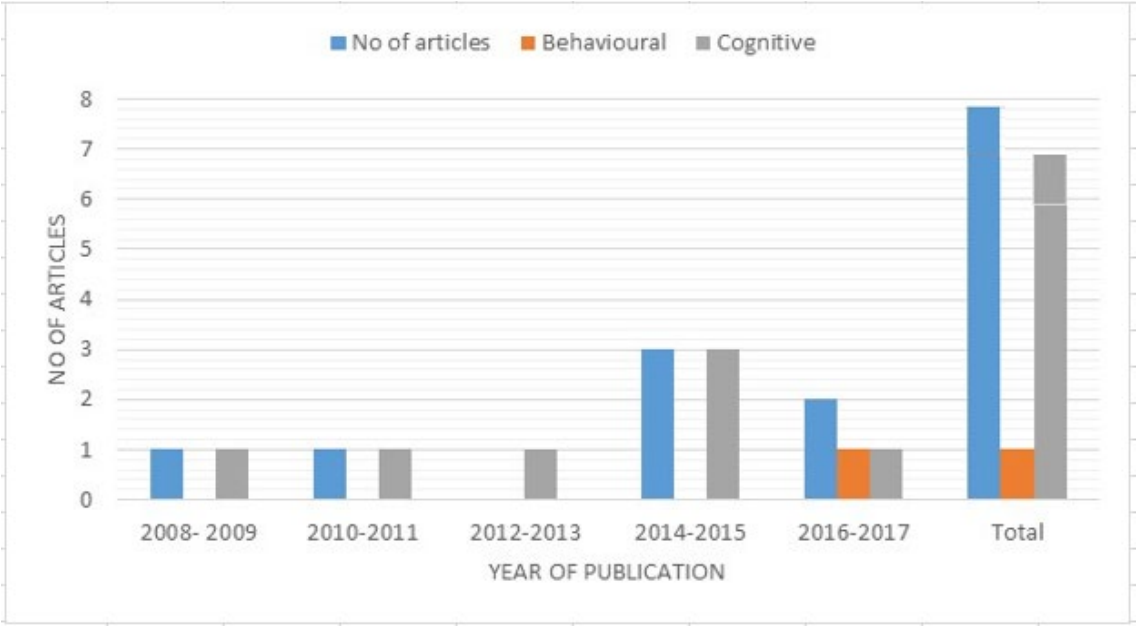

Figure 11. Percentage articles in each of the categories of research aims.

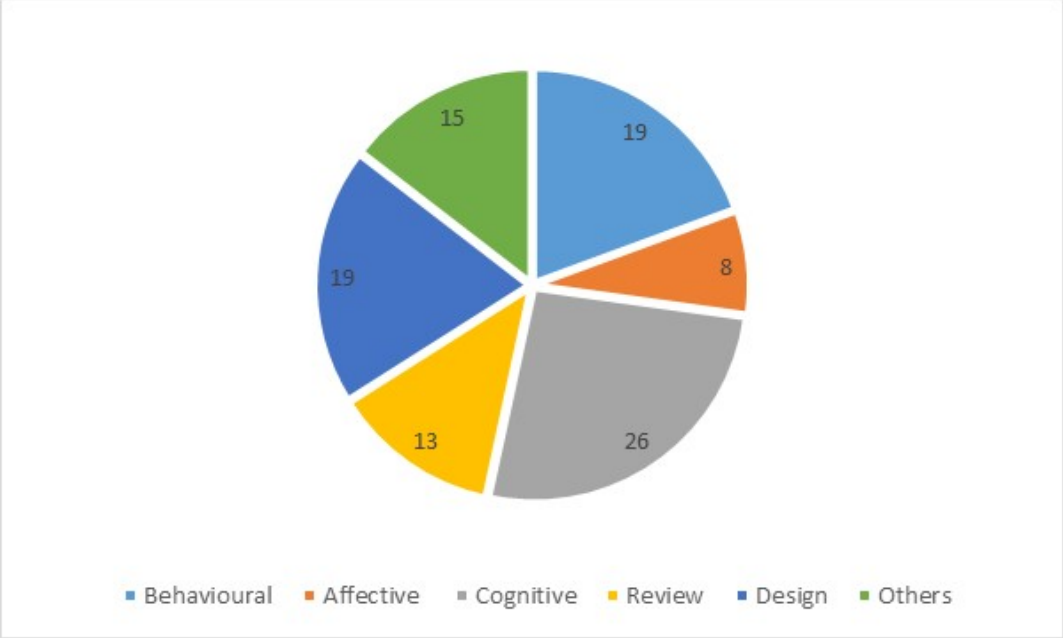

Figure 12. Distribution of methodologies used.

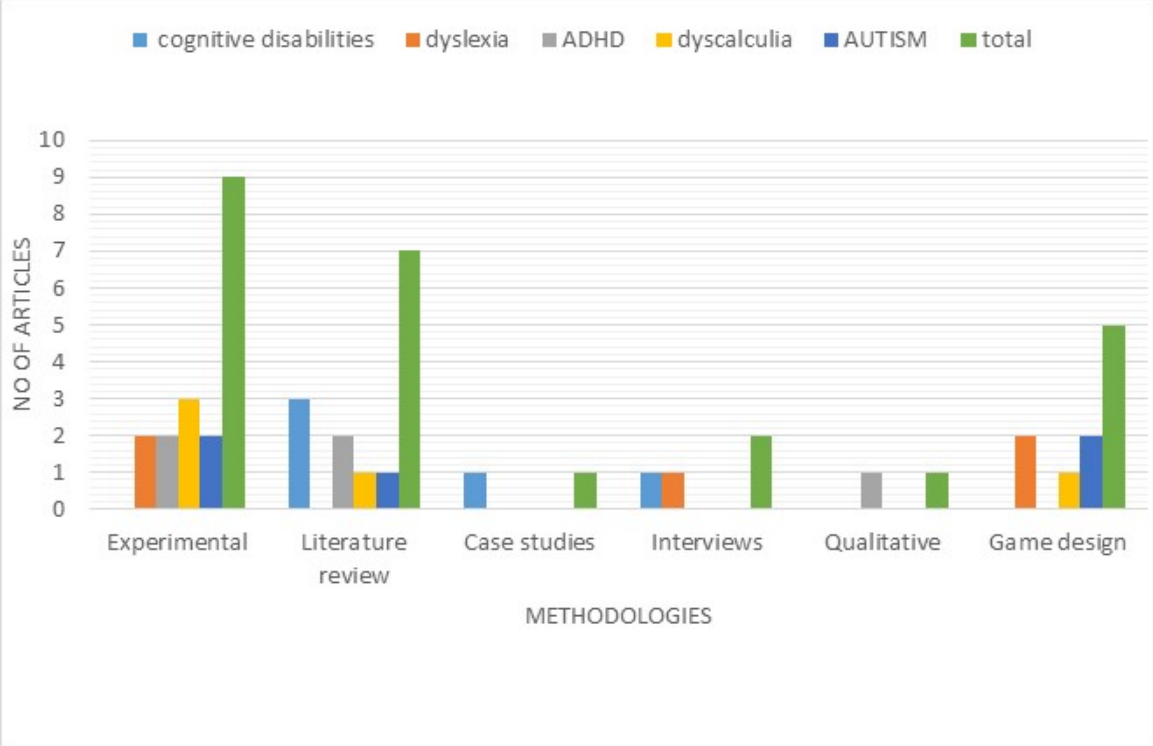

Figure 13. Distribution of outcomes.

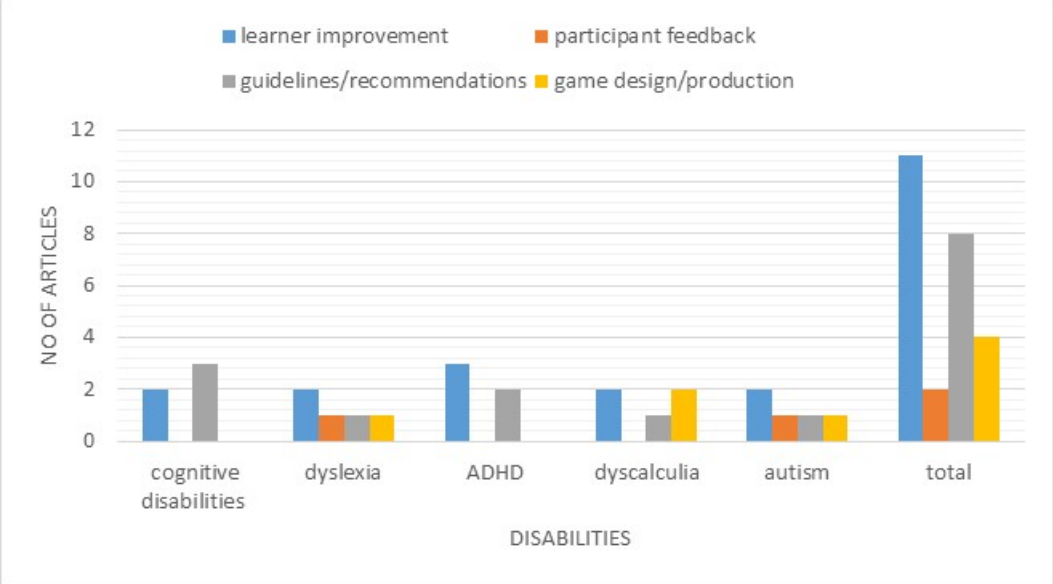

Figure 14. Distribution of study recommendations.

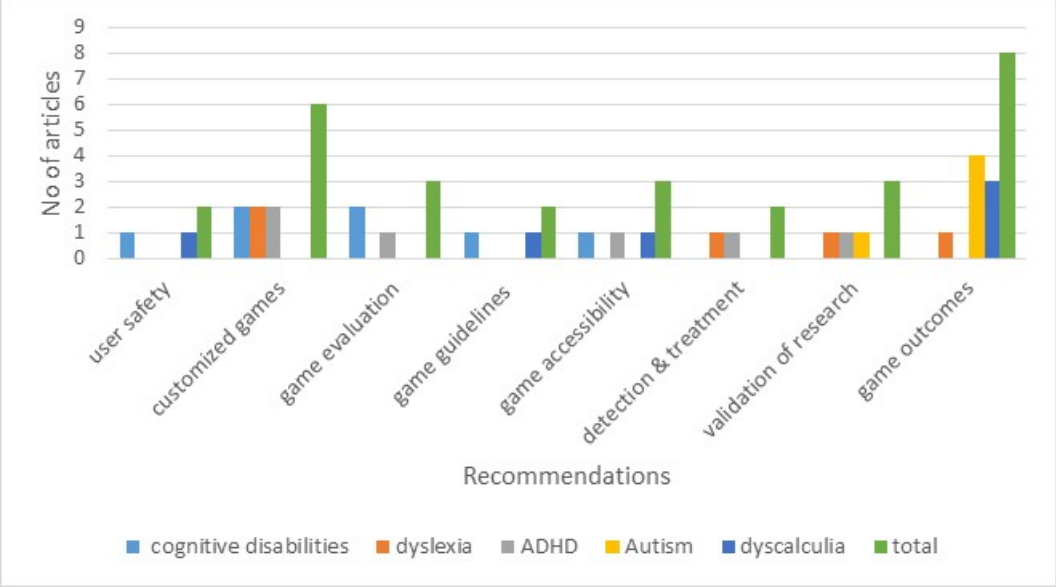
No of articles
9
8
7
6
5
4
3
2
1
0
user safety
customized games
game evaluation
game guidelines
game accessibility
detection & treatment
validation of research
game outcomes
Recommendations
cognitive disabilities
dyslexia
ADHD
Autism
dyscalculia
total

Table 1

Percentage distribution of articles in each disability/impairment type.

Type of Impairment	Percentage (%)
General cognitive impairments	28.1
Dyslexia	20.4
ADHD	10.7
ASD	34.0
Dyscalculia	6.8

Table 2

Excerpt from the coding matrix showing 10 categories

STUDY	Type of study	PURPOSE	METHOD	GAME USED	LEARNER	LEARNING TASK	Intervention period	data/ instruments/ analysis	Findings	Limitations/ Recommendation
Vasalou, A., Khaled, R., Holmes, W., & Gooch, D. (2017).	Empirical (qualitative case study approach)	To examine the situated social interactions occurring between students, and between students and their tutors, in the context of group game play focusing on how they shape engagement and learning	Systematic and thematic analysis of videos of children's verbal and non-verbal interaction triangulated with their game logs, focusing on the nature of student-student as well as student-tutor social interactions.	Words Matter - combines design features from casual and social games with evidence-based practice from special education.	Eight children (4 male, 4 female) in Year 6 (aged 11 - 12 years old)	the game involves seven skills centered on identification of consonants, vowels, blends and letter patterns, syllables, suffixes, prefixes and confusing letters & targeting children's word decoding, spelling and fluency	Participants played Words Matter over a period of ten weeks in two separate groups (Groups A and B). Game play at school occurred for a period of 30 min on a weekly basis .	Logs of the children's game play were recorded for each mini game played; video recordings of each session; a thematic analysis was used for generating codes for language patterns.	Children spontaneously engaged in 'game talk' which facilitates a strong sense of social engagement and playfulness; it also enables a variety of new opportunities for learning by initiating student-tutor interactions.	Alignment of the benefits of personalised learning with collaborative modes of learning.

Table 3

Representative Articles on Serious Games and Disabilities

	Study	Aim	Methodology	Outcomes	Recommendations
GENERAL INTELLECTUAL DISABILITIES					
1	Chuang et al. (2017)	Developing a motion-sensing digital game-based therapy to improve bodily-kinesthetic intelligence	Experimental study Interviews	Improvement and positive feedback from participants	Parental involvement in play to create a safe game environment for fostering relationship with children
2	Tomé, Pereira, & Oliveira (2014)	Using serious games for intellectual disabilities.	Literature review	Design guidelines and testing with representative users and tasks	Games to be customized to engage and cater to users' needs New games to be evaluated
3	Torrente et al. (20co)	Designing and developing serious games to support the needs of students with intellectual disabilities	Review & case studies	Need for flexibility and configurability in customizing games for learners with disabilities	Analysis of effective strategies in games Concrete guidelines for games development
4	Yuan, Folmer, & Harris, (2011)	Providing a review of the literature on research and practice in the accessibility of video games in relation to disabilities	Literature review	Effects of disability on game playing, the number of people affected and accessibility of games to the disabled	To convince game developers to increase game accessibility More data on accessibility strategies and affected users
5	Gamberini et al. (2008)	Reviewing research on computer games, focusing on the relationship between intellectual processes and gaming	Literature review	Relationship between game playing and enhancing intellectual abilities, motivation and desirable behaviours	to develop specific tasks targeting specific intellectual processes
DYSLEXIA					
1	Gaggi et al. (2017).	Evaluating the use of serious games for predicting the risk of dyslexia	Experimental study Interviews	Positive feedback from participants Successful identification of the risk of dyslexia	To detect and treat dyslexia as early as preschool for limit its impact
2	Rello et al.. (2014, October).	Using computer-based play to improve spelling for pupils with dyslexia	Experimental study Pre-and post-test scores	Improvement in dyslexic children's spelling skills	To explore additional strategies, to train writing and reading skills. To explore strategies and tasks tailored to user performance
3	Ward et al. (2012, September).	Developing digital fluency tutor to remediate poor reading among children with dyslexia	Experimental study Control and experimental voluntary reading scores	Higher scores for children in the experimental group	To involve more subjects, formal randomization, and to avoid Hawthorne effects*
4	Smythe, I., & Giulivi, S. (2010)	Describing a multinational project to develop language learning digital games for dyslexic learners	Literature review and design report	List of guidelines for design and development of serious games Tool for evaluating digital games	To produce and implement games that are exciting and motivating
5	-Lyytinen et al. (2009).	Describing the the reasons and logic behind the development of a	Literature review and design report	Identification of developmental	To create

		preventive serious game for children with a genetic risk for dyslexia		bottlenecks in children at risk Design of a serious game to reward success and minimize failure	interventions that seek to redress the imbalance of reading difficulty
ATTENTION DEFICIT HYPERACTIVE DISORDER					
1	Andersen, H. V., & Sorensen, E. K. (2017)	Using game-based activities to increase inclusion, flow and self-efficacy in learning	Qualitative – hermeneutic-phenomenological approach	Enhanced student motivation and engagement	To give all individuals equal opportunities to learn, based on their actual skills and at their own pace.
2	de la Guía et al. (2015)	Introducing a novel software system with new interaction mechanisms to improve memory and attention	Experimental study	Participants perceived that they have learned from the game but were not necessarily motivated to play the game	To assess the long-term effects of educational games on intellectual functions
3	Retalis et al.. (2014, October).	Introducing the Kinems learning games for disabled children	Experimental study	Improvement in executive functions and intellectual skills	To validate the effectiveness of the Kinems games.
4	Weinstein, A., & Weizman, A. (2012).	Reviewing findings on the mechanisms underlying computer game addiction and ADHD and the associations between the two.	Literature review	Co-morbidity between ADHD and game addiction	To investigate mechanisms for ADHD and game addiction, and the diagnosis and treatment of both conditions.
5	McKnight, L. (2010).	Exploring guidelines on usability and inclusivity identified from the literature	Literature review	Promoting accessibility through software design that is suitable for both ADHD and non-ADHD children,	To allow the users (or a parent or teacher) to customize the system to their personal requirements.
AUTISM					
1	Gillespie et al. (2017, July).	Developing a game for collaboration and social-communicative skills in autistic participants	Experimental study Game design	Student involvement and feedback on game design	To develop an engaging and game for autistic youth using the insights from the life experiences of autistic adults
2	Jung, S., & Sainato, D. M. (2015)	Investigating the effectiveness of a video modelling intervention for children with ASD	Experimental study Observations	Enhanced engagement with peers and games Decrease in inappropriate behaviour	To design games that motivate and promote spontaneous and interactive play between both children with ASD and their non-ASD peers
3	Whyte et al. (2014)	Examining the principles of serious game design and their use in computer-based interventions	Literature review	Recommendation for research on the design of the computer-based interventions Inclusion of long-term goals for individualized instructions	To design serious games that enable learning to be generalised to daily social communication and interactions.

4	Harrold et al. (2012, November).	Creating an expression recognition game to enhance positive emotional development of autistic children	Game design Literature review	Production of an engaging game to enable the capture of facial expressions and to allow emotional understanding	To implement the proposed user interface and system design for the game in order to evaluate its effectiveness in assisting the social development of children with ASDs.
5	Van Veen et al. (2009)	Developing a serious game that runs on a multi-touch tabletop	Experimental study	Higher post-test scores for collaborative skills & improvement of social behaviour in class.	To confirm preliminary results over a longer intervention period and using a larger participant sample
DYSCALCULIA					
1	Cezarotto & Battaiola, (2016, July).	Presenting a combination of studies on game design and neuropsychology for enhancing motivation	Literature review Case study	A set of game design recommendations to enhance motivation of dyscalculic user	To apply game design recommendations to overcome constraints limiting the use of the games to enhance motivation
2	Cos, A. (2015)	Evaluating changes in intellectual functions associated with remediation of dyscalculia	Game design	A game for improvement of mathematical skills A tool for assessing changes in numeracy	To make the game accessible through web browsers, To involve parent in monitoring
3	de Castro et al. (2014).	Evaluating the effectiveness of 18 serious games on maths topics	Experimental study	Improved learning for the experimental group as compared to the control	To use similar virtual environments to create teaching plans that improve students' practical knowledge
4	Käser et al., 2013	Design and evaluation of the computer-based training program Calcularis for enhancing numerical cognition	Experimental study	Children benefitted from training on number representation and arithmetic operations. Furthermore, children liked to play with the program and reported that the training improved their mathematical abilities.	To improve and extend the training program by introducing a control training and assessment of other non-domain specific measures such as attention.
5	Laurillard & Baajour, (2009).	Developing digital games adapted to the learner's needs, to promote engagement and numeracy	Experimental study	five digital programs were developed, tested and redesigned	To apply basic learning patterns to similar tasks in other topics

*The Hawthorne effect is the phenomenon whereby 'behaviour during the course of an experiment can be altered by a subject's awareness of participating in the experiment' (Jones, 1992, p.451). As such, the integrity of research outcomes may be compromised, in particular, relationships between variables being investigated.