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ARTICLE / ARTÍCULO

Inclusive Education with Serious Games and User-Centered Design, Exploring the Intersection of Accessibility and Usability

Educación Inclusiva con Juegos Serios y Diseño Centrado en el Usuario, explorando la intersección de accesibilidad y usabilidad

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Abstract: The advancement of technology enables new resources for education. The convergence of accessibility, usability, serious games (SG) and user-centered design (UCD) enables the development of inclusive resources to respond to the needs of people with disabilities. This work aims to analyze and synthesize the developments of digital educational games, focusing on the technical aspects that facilitate their implementation in the classroom. The criteria and recommendations of the PRISMA protocol (2020) were applied to carry out the search. Keywords were used to explore the databases of Web of Science, Scopus, PubMed and 21 journals, covering the period between 2018 and 2023. In the initial investigation, 799 articles were identified, and after applying the purification process 24 publications were analyzed. The results indicate a growing and continuous interest in the topic. Current trends in the design and use of accessible video games for people with intellectual disabilities were identified, as well as their impact on learning and educational inclusion.

Keywords: Accessibility, Usability, Educational Games, Educational Technology, Special Education.

Resumen: El avance de la tecnología posibilita nuevos recursos para la educación. La convergencia de la accesibilidad, la usabilidad, los juegos serios (JS) y el diseño centrado en el usuario (DCU) posibilita el desarrollo de recursos inclusivos para responder a las necesidades de las personas con discapacidad. Este trabajo tiene como objetivo analizar y sintetizar los desarrollos de juegos educativos digitales, centrándose en los aspectos técnicos que faciliten su implementación en el aula. Se aplicaron los criterios y las recomendaciones del protocolo PRISMA (2020) para llevar a cabo la búsqueda. Se emplearon palabras clave para explorar en las bases de datos de Web of Science, Scopus, PubMed y en 21 revistas, abarcando el período comprendido entre 2018 y 2023. En la investigación inicial se distinguieron 799 artículos, y luego de aplicado el proceso de depuración se analizaron 24 publicaciones. Los resultados indican un interés creciente y continuo en la temática. Se identificaron las tendencias actuales en el diseño y uso de videojuegos accesibles para personas con discapacidad intelectual, así como su impacto en el aprendizaje y la inclusión educativa.

Palabras-Clave: Accesibilidad, Usabilidad, Juegos educativos, Tecnología educativa, Educación especial.

1. Introduction

In the digital era, the convergence of accessibility, usability, serious games (SG), user-centered design (UCD) and the needs of people with disabilities has acquired relevance in academic studies for inclusive education. From an educational perspective, SG are tools aimed at learning with a playful orientation (Bossavit & Parsons, 2018; Carrión-Toro et al., 2020). The adjective "serious" refers to its educational usefulness using fun and attractive elements. A classification defines five main categories: Edutainment, Advergaming, Edumarket game, Political games, and Training and simulation games (Alvarez et al., 2007). In addition to the SG, the UCD considers the perspectives, experiences and requirements of people with disabilities to develop educational resources and personalized learning environments (Fetaji et al., 2020; Nagalingam et al., 2020; Silva Sández & Rodríguez Miranda, 2018).

Furthermore, accessibility and usability in digital environments allow us to generate equality of access and participation. As SG are integrated into teaching-learning contexts, the need arises to ensure that they are inclusive, regardless of the abilities or constraints of the context (Ben Itzhak et al., 2022; Bossavit & Parsons, 2018; Bui et al., 2020; Carrión-Toro et al., 2020; Stancin & Hoic-Bozic, 2021; Tsikinas & Xinogalos, 2020). According to authors such as (Atanga et al., 2020; Holmgren, 2023), digital technology can support special education, finding applications for the inclusion of students with disabilities. Digital resources have transformed the educational scenery by improving efficiency, accessibility, and effectiveness for individualized instruction (Holmgren, 2023).

Several authors (Kamarulzaman et al., 2021; Keselj et al., 2021; Von Gillern & Nash, 2023) point out that technology is a tool for inclusive education and promotes equal opportunities, facilitating the approach of individual needs when concepts of usability and accessibility are applied. Considering the learning of mathematics as essential for life in society, it should be accessible and attractive to everyone. Teaching benefits from the integration of appropriate technology. Thus, the SG constitute a fun instrument with a significant impact on mathematics learning (Alvarado-Cando et al., 2019; De Souza et al., 2023; Fetaji et al., 2020; Ocampo-Pazos et al., 2020; Volioti et al., 2023).

This systematic literature review (SLR), framed in this complex intersection, seeks to identify opportunities and possible solutions to promote an inclusive and accessible educational environment. It uses a multidisciplinary orientation for analysis, aligned with the sustainable development goals (SDGs), specifically SDG 4: Ensure inclusive, equitable and quality education and SDG 10: Reduce inequality within and between countries (United Nations Department of Economic and Social Affairs, 2023).

This research is located in the Northeast of Argentina, a region marked by poverty and with obstacles to access to education, especially for vulnerable groups. In particular, mathematics teaching presents additional difficulties for students from disadvantaged backgrounds or with disabilities (Krüger et al., 2022; Maldonado Valera et al., 2020; Pinto, 2020).

2. Method

The objective of this SLR is to analyze and synthesize digital resources. It focuses on the integration of aspects of accessibility, usability, inclusive education, SG, and UCD to improve the educational experience and promote equal opportunities, active participation and quality education.

2.1. Design of the investigation

This SLR seeks to know the current state of the research area (Marín, 2022). The PRISMA method is used (Ouzzani et al., 2016; Page et al., 2021) and the methodological guidelines for analysis of scientific documents by (Sánchez-Meca, 2022). The phases used are: (1) formulation of the question, (2) definition of the study selection criteria, (3) search and location of the studies, (4) extraction of information from the studies, (5) measurement of the results of the studies, (6) synthesis and interpretation of the results and (7) writing. In addition, the recommendations of Marín (2022) are considered, identifying factors such as the need for implementation, the existence of sufficient published literature on the topic, asking if the research question can really be answered and if there is enough time to carry it out.

2.2. Research question

The aim is to establish a base of knowledge and guidance to identify inclusive pedagogical practices adapted to the specific needs of the regional context, with the goal of improving educational quality and promoting equity in access to education. Following this premise, the guiding question of the study is posed: What is the impact of accessibility, usability, UCD and SG strategies in the context of inclusive education to improve learning in teaching environments?

2.3. Inclusion-exclusion criteria

These criteria determine the characteristics that a study must meet to be considered in the SLR. Articles published in the last 6 years (from 2018 to 2023) that provide statistical data to allow a numerical estimation of the results are considered (Sánchez-Meca, 2022). Table 1 details the specific inclusion and exclusion criteria that will be used in this selection process.

2.4. Search and location of studies

Articles published between 2018 and 2023 in the Web of Science, Scopus, PubMed databases and in 21 journals belonging to the education and technology category, open access social sciences area, in Scimago Journal & Country Rank (SJR) were reviewed. The choice of the last six years focused on addressing the most recent research, capturing current trends and advances. Qualification and coverage were considered for the databases, ensuring the identification of quality publications, relevance, and the support of peer review.

Table 1. Inclusion/exclusion criteria.

Topical	Inclusion Criteria	Exclusion Criteria
Publication Year	2018 to 2023	Before 2018
Methodological approach	Experience with educational SG mediated with technology (software) focused on design with accessibility, usability and UCD criteria	Experience with non-tech educational SG (not software development). Not being focused on the accessibility, usability and UCD criteria
Language	English or Spanish	Another language
Results	Explains work methodology and coherent and objectively measurable results	It does not present methodology, it does not present results, there are no elements that allow objective measurement. It does not include case studies or validation of the proposal.

The Spanish language preference seeks to achieve research linked to the Hispanic context, and English to expand to global studies allowing an international perspective.

The following search terms were adopted: accessibility, usability, serious games, inclusive education, UCD, learning, disability, and special education. With them, the chain was set up ("accessibility" OR "usability" OR "user-centered design") AND ("serious game" OR "educational games" OR "games for learning") AND ("inclusive education" OR "inclusion education" OR "disability" OR "special education"), adapting the format to the bases consulted.

Publications were recorded in Web of Science (n = 529), Scopus (n = 136), PubMed (n = 42) and educational journals (n = 92). Publications prior to 2018 (n = 250) and duplicates (n = 23) were eliminated. Then, the inclusion/exclusion criteria were applied. Figure 1 shows the procedure for identifying studies. Figure 2 represents the key words of the research, where accessibility (red), play (green) and learning (green-yellow) emerge most strongly.

2.5. Extraction of study information

Information extraction was carried out systematically, recording data such as authors, year of publication, methodologies used, main results and conclusions. It was synthesized and organized according to the objectives of the SLR (table 2).
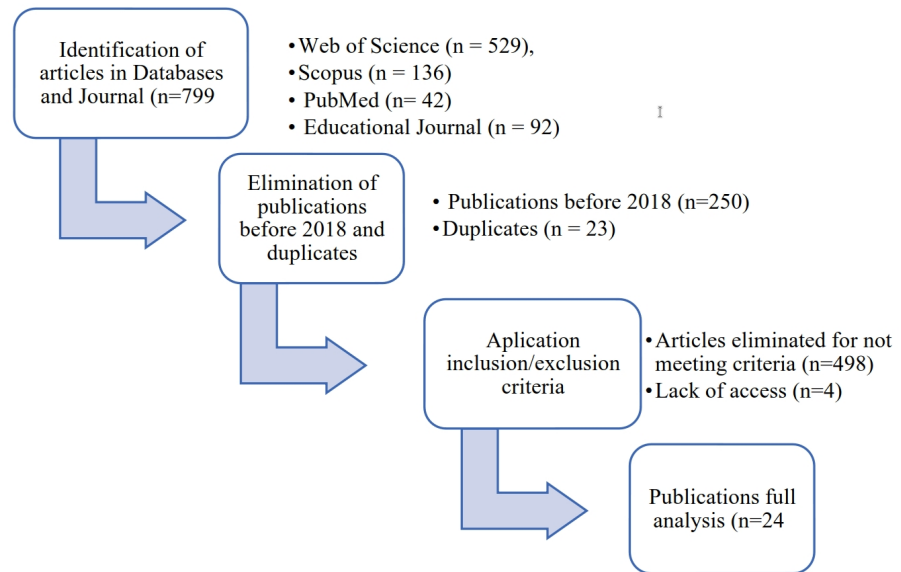
Figure 1. Process diagram for searching and locating studies, following the PRISMA model.

2.6. Measurement of study results

To evaluate the results of the studies, metrics were used in response to the research question:

— Technology and accessibility in serious games: measures such as ease of use, adaptability, availability of aids and interoperability with other systems were analyzed.

— Impact of accessibility on education: indicators such as diversity of benefited students, equity in access, participation of marginalized groups and improvement in the educational experience of students with special needs were examined.

— Inclusion and accessibility: the effectiveness of the strategies was evaluated by measuring variables such as participation in the learning process, knowledge retention, student satisfaction, and improvement in specific skills.

— Impact on learning: measures related to academic performance, achievements in evaluations, progress in key competencies and evidence of significant learning were considered.
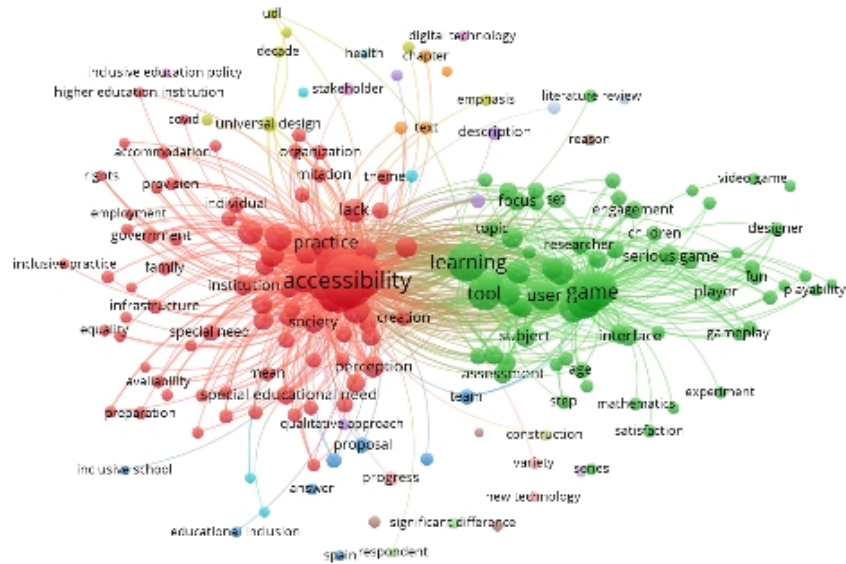
Figure 2. Terms used in studies

2.7. Synthesis and interpretation of the results

The measures applied provided a comprehensive and comparative evaluation of the results obtained, and summarized in tabular form (Table 2) the most important aspects in methodology, results and conclusions.

3. Results

The result reveals an increase in publications in recent years. This temporal pattern shows the current relevance and constant evolution of knowledge in the area of interest (figure 3).
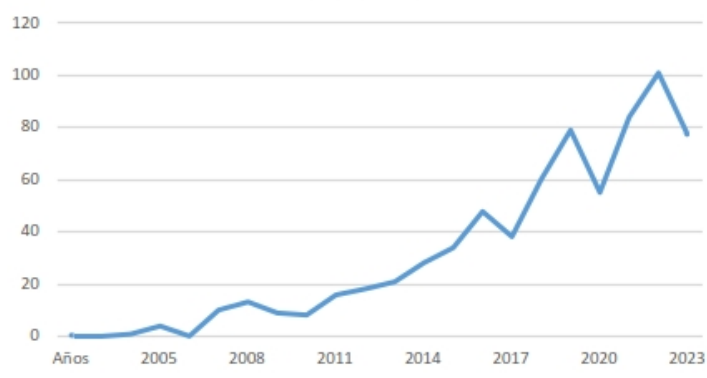

Figure 3. Scientific production of the consulted databases (Scopus, Web of Science and PubMed).

Of the 24 investigations included in the SLR, published in 17 countries (figure 4), 95.83% (n=23) were written in English and 4.17% in Spanish (n=1). In particular, Ecuador and Greece showed greater productivity in the subject (n=3), followed by China, Croatia, and the United States (n=2) and finally Belgium, Brazil, Canada, the Philippines, Finland, India, Indonesia, Macedonia, Malaysia, Netherlands, United Kingdom and Tunisia (n=1). Figure 4 shows that the majority, 41.67%, of the publications are located in European countries (n=10), then with 29.17% America (n=7), 25% Asia (n= 6) and finally with 4.17% Africa (n=1).

Table 2 summarizes the studies included in the SLR, detailing the substantial elements of the methodology, results and conclusions, ordered alphabetically by author.

Table 2. Summary of studies with details of methodologies, results and conclusions.

Author (year)	Methodology	Results	Conclusions
Alvarado-Cando et al. (2019)	Educational software based on eye tracking to assess the mathematics abilities of children with cerebral palsy. It was tested by children aged 5 and 7 years (5 students).	Four of the five students earned a higher grade using the system relative to the traditional one. Student 3 improved his grade by 18%.	Technology can improve the academic performance of students with special educational needs, highlighting their educational support.
Ben Itzhak et al. (2022)	Describes the design, development and evaluation of a set of individualized and adaptive mini-SG for visual perceptual skills. They were designed for six types of visuoperceptual skills for children with cerebral visual impairment. It was evaluated by experts.	The designed mini-games evaluated in terms of effectiveness, efficiency, operability and attractiveness indicated satisfactory results. The children's positive responses are shown, suggesting that they enjoyed the games.	These games are useful for improving children's vision and visual processing. Provides a useful perspective for the design of educational games for children with visual impairments.

Author (year)	Methodology	Results	Conclusions
Bossavit & Parsons (2018)	Pilot study that analyzes a video game co-designed with young people with autism spectrum disorders (ASD) to learn geography. It was evaluated in 5 sessions by 3 peer teams from 2 different special educational institutions, with 6 students with ASD.	They showed that the level of competitiveness of the players not only influenced the experience within the game, but also the interaction within peer teams, and that the game helped participants with ASD increase their knowledge in geography.	The students enjoyed the game, finding it easy to use. Social behaviors were positive throughout the period. They improved their knowledge in geography.
Bui et al. (2020)	Analyze the experience of playing Number Navigation Game (NNG). It uses a mixed, quantitative and qualitative methodology. It works with three cross-sectional data sets collected in different phases of NNG development. 1,168 public school students from fourth to sixth grades in four cities in Finland participated during spring 2014 .	They show that there is an advantage to having better aesthetics and value in extrinsic elements, helping to maintain the enthusiasm and situational interest of the SG.	They express an improvement in mathematical understanding. Quantitative and qualitative methods were suitable for evaluating effectiveness. They indicate that the usability and clarity of the interface made it possible to provide positive, fluid and immersive experiences.
Carrión-Toro et al. (2020)	It uses the iPlus methodology for SG design and analyzes various application cases. Its goal is to design SG with a user-centered and educational approach.	The results of a survey applied to 40 participants to evaluate the usability of educational games obtained average satisfaction scores of around 85%.	They ensure that, for the success of a SG, a methodology must be applied that incorporates fun game mechanics, high intrinsic motivation and a positive experience. The proposed metamodel allows us to understand each of the concepts used to design a SG.

Author (year)	Methodology	Results	Conclusions
Chrisyarani et al. (2021)	RS of interactive educational games and their evaluation in terms of their quality. It was carried out through tests with experts. The heuristic method was used to evaluate the suitability of the game for end users and to identify usability and technical problems. Use descriptive research.	Minor cosmetic issues were found; however, the game is suitable for distribution. There was a slight usability problem in error prevention, obtaining an average of 2.33.	Provides information on evaluating the quality and reliability of software used in creating educational games and how these can be beneficial to education to motivate and enhance learning activity.
Dash et al. (2023)	PlutoAR is a mobile Augmented Reality (AR) interpreter designed for inclusive, cheap, immersive, portable and safe learning for children. Develops basic concepts of programming, arithmetic and computational thinking. Presents information in 3D models. 415 individuals between 10 and 45 years old participated.	They suggest that PlutoAR is a useful, easy-to-use and satisfactory application for users of different age groups.	Reliability and usability have been tested by analyzing user comments anonymously and with an unbiased approach. Reliability and usability are considered acceptable after qualitative and quantitative analysis.

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Author (year)	Methodology	Results	Conclusions
De Souza et al. (2023)	It presents a digital domino game adapted to teach multiplication to children, using the stimulus equivalence paradigm. The performance of five students with low academic level in solving multiplication operations is evaluated before and after playing.	They indicated that the students learned the relationships taught well and that there was an increase in the percentage of correct answers.	The use of additional teaching tools, such as games, can improve students' performance in mathematics.
Fetaji et al. (2020)	Investigates the impact of educational games as an instructional strategy within the Mathematics course in Secondary School. Develop a mobile math game for Android devices, as a case study, and evaluate student achievements. It uses a quantitative research methodology and a questionnaire.	Collect data before and after playing, so you can evaluate the difference between time spent and level of knowledge transferred. The functionalities and usability are evaluated in two groups of users, one with experience in computing and the other with novice users.	Contribute to identified impact factors for such systems, analysis of improvement in ease of use and usability. Ideas and recommendations are provided.

Author (year)	Methodology	Results	Conclusions
Jeblaoui et al. (2019)	It introduces an educational game (Choice-Game) and proposes several scenarios to extract a specific characteristic of the student (the student's values).	The scenarios and player data collection for each are described.	An adaptive e-learning system can be used to provide them with personalized materials and recommendations that positively impact their process. It presents a limitation: using only eight scenarios cannot help collect enough data about the student.
Kaimara (2023)	It describes two data collection instruments that include detailed questionnaires on the demographic characteristics and attitudes of pre-service teachers towards inclusive education and digital educational games. The sample consisted of two hundred and sixty-five (265) undergraduate students from twenty-five Pedagogical Departments of Greek Universities.	They showed that the majority of participating pre-service teachers had positive attitudes towards inclusive education and DEGs, and saw great potential in using DEGs in inclusive educational programs. Furthermore, some barriers and challenges were identified that could hinder the effective implementation of inclusive education and the integration of SDRs into inclusive educational programs.	Provides a comprehensive and detailed overview of international efforts and current challenges related to inclusive education and digital educational games.

Author (year)	Methodology	Results	Conclusions
Keselj et al. (2021)	Implementation of accessibility in mobile AR applications for educational purposes. It is an application for teaching geometric bodies, and focuses on making educational technologies accessible to people with disabilities. The ARGeoBody app was used in schools alongside traditional teaching methods, evaluated with 88 participants, most (but not all) of whom are typically developing students at Ivan Gundulić Primary School in Dubrovnik, Croatia.	94.7% reported that the purpose of ARGeoBody is clear, the design is functional and the functionality of the screen reader is satisfactory, it was confirmed that the design follows the third UD principle (simple and intuitive use). The first UD principle (equitable use) was satisfied, 84.2% of participants thought that the questions were clear and that the design was accessible.	It can help make content more easily accessible and understandable by providing a hands-on, immersive learning experience. They stand out: making the interface easier to use and providing accessibility options adjusting to those specific needs. Mentions the need to involve accessibility experts in planning and design to ensure the needs of students with disabilities are met.
Maqsood et al. (2018)	Series of three empirical studies to evaluate the usability and effectiveness of the educational game for young people between 11 and 13 years of age.	The game managed to significantly improve children's digital literacy and intended behavior after using it.	Positive impact on digital literacy and could be used in educational environments.

Author (year)	Methodology	Results	Conclusions
Nagalingam et al. (2020)	It focuses on creating a framework and questionnaire for evaluating educational games. The framework includes six user experience elements and the questionnaire is used to evaluate the educational game in terms of usability, immersion, game flow, player context, game system and learnability.	The validity of the questionnaire used in the study was evaluated with the content validity index (CVI). A complete list of the items and their CVIs is provided.	Evaluation helps ensure that the educational game meets the expectations and interests of the intended user and the desired educational outcomes. A suitable user experience (UX) tool for an educational game will make the work of game designers easier and help create effective educational games.
Ocampo-Pazos et al. (2020)	RS on educational video game for logical-mathematical thinking in basic education. It asks five questions on topics of software standards, education, design guides and evaluation methods.	Game-based learning can be developed with various technologies (AR, virtual reality, robotics and the Internet). The design should be based on the technological environment, focused on STEM (Science, Technology, Engineering and Mathematics).	Mathematical video games based on Game-based Learning allow the student to build or develop mathematical logic through experimental learning. The need to increase students' interest in STEM subjects and to promote critical thinking and active learning is highlighted.

Author (year)	Methodology	Results	Conclusions
Own et al. (2023)	A mathematical application called The Numbers was designed to compare the learning potential of preschool children and eye tracking was used to assess cognitive differences between Tangible User Interfaces (TUI) and Multi-Touch Interfaces (MTI) versions. The sample was composed of 32 students (16 girls and 16 boys) from kindergarten at Tianjin University, aged between 4 and 5 years. A pre-test was conducted using Numeracy Screener to assess their mathematical arithmetic skills.	According to the pretest results, the participants were equally divided into group T and group M, with 16 students in each group. Eighteen participants preferred the TUI version, ten participants preferred the MTI version, and four participants liked both or did not know which they preferred. They demonstrate that there are significant differences in cognitive load between both versions and that one version has better performance than the other.	The TUI version provides a higher cognitive workload, increases attention in key areas and provides greater entertainment value, which has long-term effects in promoting children's learning. The TUI version is easier to use, more interesting and more motivating for preschool children than the MTI version.
Reed et al., (2020)	Qualitative and quantitative research describing the perception and interaction of high school students in grades 6-8 with game elements incorporated into a reading assessment.	The use of gamification can be beneficial, especially for students with reading difficulties, as long as it suits their abilities and is not frustrating. The gamified reading assessment was more motivating than the traditional form of assessment.	Gamification of reading assessment can be effective in motivating students and improving their performance on the reading task, but implementation must take care of the design to ensure that the task remains relevant and faithful to the skill assessed.

Author (year)	Methodology	Results	Conclusions
Stancin & Hoic-Bozic (2021)	The objective is to analyze and evaluate the impact of digital games on education and inclusive learning and develop new models of digital games to support education and increasing educational inclusion.	The analysis showed that the area of social-emotional skills for students with intellectual disabilities is not sufficiently covered. There are no games available that develop this area such as the ability to recognize and understand feelings and emotional states.	Digital games can be a useful tool to improve the learning of students with intellectual disabilities, and have been used in recent research.
Tsikinas & Xinogalos (2020)	This is the SG design framework for people with intellectual disabilities or autism spectrum disorder. Proposes a SG Design Framework (GDF) to help designers and educators develop successful Ss for people with intellectual disabilities (ID) and autism spectrum disorders.	In GDF the pedagogical elements and mechanics are developed. Prototype acceptance evaluations and adjustments are carried out to improve the user experience. Usability tests serve to identify advantages and flaws by improving the game iteratively.	The game design framework is built based on elements and guidelines for people with ID and ASD, they consider that it could be used to design general purpose SG, with some modifications.
Veldkamp et al. (2022)	Research escape games and design elements such as immersion, collaboration and feedback influence learning. It was tested with 126 students between 16 and 20 years old and their gaming experience was measured, with their pre- and post-tests. Interviewed students and teachers.	The immersion element had a direct contribution to the knowledge acquired. The objects used in the game helped the students.	The framework helps educators and researchers develop and evaluate escape games that enable immersive environments such as real-world contexts related to science or socio-scientific issues and benefit learning.

Author (year)	Methodology	Results	Conclusions
Volioti et al. (2023)	Implements AR in primary education, focusing on mathematics and active learning in the classroom. Describes the intuitive and interactive "Cooking Math" application. It focuses on cooking problems and recipes for sixth grade. A pilot study was carried out for evaluation and questionnaires and semi-structured interviews to measure the level of satisfaction and involvement.	They indicated that the app was effective and improves the learning experience for students. The SUS (System Usability Scale) questionnaires were satisfactory for all groups, with a total SUS score of 70.01.	Technology has the potential to transform education and improve learning in primary schools through the creation of a more engaging, interesting and interactive educational environment.
Von Gillern & Nash (2023)	Discusses types of disabilities and how they affect the ability to participate in a video game. Explore how to make games more accessible for people with disabilities. Suggests ways for English teachers to use video games in reading and writing skills.	Accessibility must address aspects such as visualization, hearing, mobility and cognition. Text size and color, contrast, subtitles, easy navigation, clarity of content, and access to basic instructions should be considered to ensure the inclusion of users with diverse abilities.	Video games are useful for improving English reading and writing skills. Accessibility in your design is crucial for your enjoyment. Developers must include subtitles and audio options. Universal Design for Learning promotes inclusion and learning for all.

Author (year)	Methodology	Results	Conclusions
(Xiong et al., 2022)	Analyzes the influence of digital educational games on the creative thinking of preschool children. The digital educational game "Thinking Paradise" was developed to train children's creative thinking, and the training effects were evaluated on 102 children aged 3 to 6 years.	They showed that the digital educational game significantly improved all indicators of children's creative thinking, and that the training effect varied depending on the children's age.	When developing digital educational games for preschoolers, you should consider their age and adapt the content to strengthen their skills. The training of creative thinking from an early age and game preferences and difficulty levels for different ages are highlighted.
Yabut et al. (2019)	Development of an educational mobile game application for third grade students in mathematics (Math's Going On). 37 students participated, 25 were chosen for the scheduled session. Pre- and post-test were used. The quality of the application was evaluated according to ISO 9126. The evaluation was carried out by five mathematics teachers from the Sto Catholic School. Child.	The teacher's evaluation obtained in terms of functionality an average of 5.00 (Excellent), reliability an average of 4.40 (Very Satisfactory), usability an average of 5.00 (Excellent). Math's Going's overall satisfaction rating is 4.80, Excellent. It is useful for teachers to monitor student progress.	The app has proven to be effective for students who have different learning styles. It is suggested to implement and use as reinforcement in mathematics learning. More longitudinal studies are recommended to effectively evaluate the variables.

3.1. Technology and accessibility in serious games

The results of the SLR emphasize that SG are gaining relevance in the field of education and digital learning (Bossavit & Parsons, 2018; Carrión Toro, 2022; Reed et al., 2020; Tsikinas & Xinogalos, 2020). The publications point out how through the SG, participants face individual or group challenges, putting their technical skills into practice and making responsible decisions (Carrión-Toro et al., 2020; Stancin & Hoic-Bozic, 2021; Tsikinas & Xinogalos, 2020).

Furthermore, several authors mention that usability and accessibility can be integrated into SG. The development of SG accessible to everyone, regardless of their individual abilities, promotes an enriched educational environment (Bui et al., 2020; Carrión Toro, 2022; Stancin & Hoic-Bozic, 2021).

Dash et al. (2023) and Volioti et al. (2023) highlight AR tools for the visualization of complex concepts in real time, providing immersive experiences in the real and virtual world. This technology makes it easier to understand difficult content and overcomes the limitations of traditional, static learning environments. AR enriches education by actively engaging students, allowing them to explore and apply knowledge in practical ways. This dynamic and participatory approach improves information retention, and encourages meaningful learning (Dash et al., 2023; Keselj et al., 2021; Reed et al., 2020; Volioti et al., 2023).

3.2. Impact of accessibility on education

The impact of accessibility on education is significant, especially in the context of teaching people with intellectual disabilities. Various studies (Alvarado-Cando et al., 2019; De Souza et al., 2023; Fetaji et al., 2020; Ocampo-Pazos et al., 2020; Reed et al., 2020; Rodriguez-Ascaso et al., 2018; Volioti et al., 2023; Yabut et al., 2019) have highlighted the relevance of using teaching materials adapted to the student, considering how they stimulate learning, and promote sensory experiences that facilitate the development of mathematical skills (Rodriguez-Ascaso et al. al., 2018; Yabut et al., 2019). This acquisition is usually cognitively challenging where the approach focused on accessibility is essential to overcome educational barriers. These studies highlight the role of teachers in implementing adaptations.

3.3. User-centered approach

Studies emphasize the relevance of game usability and clarity in the user interface to provide positive gaming experiences (Bui et al., 2020), of assistive technology in the education of students with special needs (Alvarado-Cando et al., 2019), the active participation of different stakeholders, including product owners, end users and pedagogical experts, in the game design process (Carrión Toro, 2022), the motivation of students and the improvement of their activity (Chrisyarani et al., 2021). The design must adjust its work in a user-centered approach to respond to the specific needs of the student (Bossavit & Parsons, 2018; Carrión Toro, 2022; Reed et al., 2020).

3.4. Inclusion and Accessibility

The results of the SLR highlight that the technology developed with the appropriate approach allows improving the academic performance of students and constitutes an inclusive tool (Alvarado-Cando et al., 2019; Ben Itzhak et al., 2022). It promotes more positive and understanding play experiences of special needs (Bossavit & Parsons, 2018; Bui et al., 2020; Carrión Toro, 2022; Chrisyarani et al., 2021; Dash et al., 2023; De Souza et al., 2023; Fetaji et al., 2020; Jeblaoui et al., 2019; Reed et al., 2020).

3.5. Impact on learning

The results obtained in most of the works show higher scores from the participants after using the application, evidencing significant learning. In general, the studies

indicate an improvement in the level of knowledge transferred, highlighting the importance of functionality and usability in the acceptance of educational games (Carrión Toro, 2022; Dash et al., 2023; De Souza et al., 2023; Fetaji et al., 2020; Jeblaoui et al., 2019; Aesthetics and the improvement of extrinsic elements contributed to the enthusiasm of the players, motivating learning (Bui et al., 2020; Reed et al., 2020). Some authors recommend the use of innovative educational platforms and teacher training to achieve the implementation of technology in the classroom (Ocampo-Pazos et al., 2020; Reed et al., 2020).

4. Conclusions

The analysis to answer the research question has shown that the effective integration of accessibility, usability, UCD and SG strategies in the context of inclusive education has a positive impact on access, and at the same time improves the learning experience for the students. These strategies are fundamental to comply with the principles of quality and equity in education (United Nations Department of Economic and Social Affairs, 2023), and contribute to comprehensive training with active participation, recognizing the diversity of student abilities.

The studies reviewed show a varied and enriching perspective on the impact of SG, usability, accessibility and educational games in the academic field. The methodological and technological diversity used in these works demonstrate the complexity and breadth of this field of research. In this perspective, attention to inclusion and accessibility influents to achieve an equitable education. The ability of SG to adapt to different barriers and satisfy a variety of abilities demonstrates its potential contribution to more inclusive and accessible educational environments (Keselj et al., 2021; Reed et al., 2020; Rodriguez-Ascaso et al., 2018; Silva Sández & Rodríguez Miranda, 2018; Von Gillern & Nash, 2023).

Another contribution of the studies analyzed are the considerations on usability and user experience in educational technologies. Consideration of preferences and personalization emerge as critical factors for the design of technologies that truly connect with students (Alvarado-Cando et al., 2019; Ben Itzhak et al., 2023; Bossavit & Parsons, 2018; Bui et al., 2020; Dash et al., 2023; Maqsood et al., 2018; Ocampo-Pazos et al., 2020; Own et al., 2023; Reed et al., 2020; Stancin & Hoic-Bozic, 2021; Yabut et al., 2019).

Regarding the impact on learning, the positive results of several studies support the idea that the integration of SG in educational environments can generate significant improvements (Alvarado-Cando et al., 2019; Ben Itzhak et al., 2023; Bossavit & Parsons, 2018; Hoic-Bozic, 2021; Yabut et al., 2019). The combination of quantitative and qualitative methodologies offers a more complete view of effectiveness and user experience. This comprehensive approach highlights the importance of understanding academic performance, and at the same time the perception of students in the educational process (Bui et al., 2020; Nagalingam et al., 2020; Veldkamp et al., 2022; Xiong et al., 2022).

In conclusion, the analysis carried out highlights the importance of user experience and usability as fundamental pillars in the design of educational tools. The consideration of preferences and the personalization of learning experiences are basic

elements to achieve student motivation. Usability and accessibility features consolidate an inclusive approach to ensure equitable access to all students, regardless of their individual abilities.

This discussion shows the importance of an inclusive and accessible UCD in SG, to fully take advantage of the potential of technologies and achieve educational inclusion. Within the framework of this study, a solid base of knowledge and guidance has been established to identify inclusive pedagogical practices applicable to the specific needs of individuals with disabilities. The results obtained demonstrate tangible improvements in accessibility, usability and UCD in SG, thus contributing to promote equity in access to education and raising the quality of teaching in the region.

Despite the aforementioned contributions, some limitations are recognized, such as the small sample size (Alvarado-Cando et al., 2019; Bossavit & Parsons, 2018; Maqsood et al., 2018; Reed et al., 2020). The need arises for longitudinal research with exploration of new technologies for a more complete understanding of educational practices (Reed et al., 2020; Tsikinas & Xinogalos, 2020; Veldkamp et al., 2022; Volioti et al., 2023; Von Gillern & Nash, 2023; Xiong et al., 2022).

In future lines of work, it is planned to continue the deepening and detailed study of the techniques and strategies identified to formulate design principles. The purpose is to develop an application that specifically contemplates and responds to the educational needs of the local environment. This initiative seeks to facilitate the incorporation of people with disabilities into life in society through inclusive learning opportunities adapted to their individual demands.

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