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PAPER

Application of Learning Software in Basic Education Students with Intellectual Disabilities: A Systematic Review of the Literature

Alfredo Leonidas Vasquez Ubaldo[1], Vanessa Yeny Gutierrez Barreto[1], Fernando Sierra-Liñan[2], Michael Cabanillas-Carbonell[3](✉)

[1]Facultad de Ingeniería y Negocios, Universidad Norbert Wiener, Lima, Perú

[2]Facultad de Ingeniería, Universidad Privada del Norte, Lima, Perú

[3]Vicerrectorado de Investigación, Universidad Norbert Wiener, Lima, Perú

mcabanillas@ieee.org

ABSTRACT

The world is currently facing the problem of the lack of education in basic education for students with intellectual disabilities. Therefore, it is important to follow up and monitor the various learning software that helps to address this problem. The study carried out is a review of scientific literature, which gathers research and studies, through a search in several databases: Dialnet, EBSCO, ERIC, IEEE Xplore, Redalyc, SAGE, ScienceDirect, Scopus, and Wiley. Likewise, according to certain previously defined inclusion and exclusion criteria, a total of two hundred (200) scientific articles were systematized, showing the digital technologies that facilitate the control, follow-up, and monitoring of the education of these students.

KEYWORDS

learning software, intellectual disabilities, teaching, education

1 INTRODUCTION

According to the United Nations (UN) [1], a fundamental right we all have is education, as it is a key driver of social development and one of the most effective tools for reducing poverty, improving health, and achieving gender equality, peace, and stability. In addition to generating high and consistent returns in terms of income, it is the most important factor in ensuring equal opportunities.

There is no doubt that lack of education can negatively impact society, health, and the economy. This is not only because educational deprivation often spans generations, but also because it perpetuates a vicious cycle of entrenched poverty. Education can be the key to lifting marginalized children and adults out of poverty and exclusion, allowing them an active role in the processes and decisions that affect them [1].

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However, it is a privilege for people with intellectual disabilities to use it, which ironically happens only for those who live in an environment with fewer attitudinal, structural, and institutional barriers [2].

Similarly, according to the International Network of Education Institutes (INEI), there are a large number of children and young people who do not have access to education due to their disabilities, which are divided into five: motor or physical, sensory, mental, intellectual, and multiple [3].

Also, according to the author [4], the United Nations Educational, Scientific and Cultural Organization (UNESCO) identifies that education systems adopt three discriminatory approaches to people with disabilities. These are exclusion, segregation, and integration.

According to research [5], [6] generally, most children with intellectual disabilities do not attend schools because they do not receive adequate education that allows them to learn, because the learning process for them is still traditional [7]; however, this method does not provide them with the same opportunities. For this reason, the educational methods provided to children with intellectual disabilities should be improved, with the understanding that their disability should not prevent this population from learning, but that each child requires personalized materials that are adapted to them.

In consideration of this, it is necessary to achieve, on the part of the governments of each nation, the design, elaboration, and development of public policies that seek the promotion of inclusive education. However, it should be noted that these policies must guarantee that every child has access to quality education, regardless of culture, religion, or other customary practices.

In one study [8], technological tools that help people with intellectual disabilities were implemented in the educational system, demonstrating that by integrating technology into the educational system, inclusive education can be achieved. These tools provide the ability to complement the usual teaching processes for students with special needs. In addition, this instrument provides greater interest and motivation in children [9].

In this context, it is convenient to gather as much information as possible regarding the use of learning software in students with intellectual disabilities, thus achieving multiple benefits, as it allows researchers to identify, evaluate, interpret and synthesize all existing and relevant research on this particular topic of interest.

For all the aforementioned reasons, the present research work is very important, as it aims to contribute to the generation of new knowledge to be taken into consideration by the educational systems. In the same line, the objective of the research is to make use of criticism and previous studies in an orderly, precise, analytical, rigorous, and impartial manner so that it has a high scientific value.

The present study focuses on analyzing the results obtained by the application of educational software in basic education for students with intellectual disabilities.

Finally, it is worth mentioning the structure of this research work, which is as follows: in Section 2, the methodology used is presented; in Section 3, the results obtained are detailed; in Section 4, the results are discussed; and finally, in Section 5, our conclusions are presented.

2 METHODOLOGY

To develop the present research work, it was decided to use systematic review as a fundamental strategy.

A systematic review helps in the identification, validation, and interpretation of all relevant existing research on a research question, field, phenomenon, or thematic area [10]. Accordingly, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is a necessary method for the critical evaluation of published systematic reviews, although it is not a tool for assessing their quality.

2.1 Research methodology

To develop the present research work, it was decided to use PRISMA as the research methodology.

According to Kitchenham, the PRISMA statement is the minimum evidence-based element to help report systematic reviews and meta-analyses. It is intended to assist authors in reporting these reports, even though they are based on randomized trials [11]. Accordingly, PRISMA is a necessary method for critical appraisal of published systematic reviews, although it is not a tool for assessing their quality.

2.2 Type of research

To develop this research work, it was decided to use qualitative research as a type of research. Qualitative research is based on making narrative records through participatory observation and obtaining primary studies to build a well-supported theory [12]. Accordingly, qualitative research produces knowledge through the collection and synthesis of updated information on a particular topic without having to resort to empirical data collected in primary research.

2.3 Research questions

The proposed research questions were the following:

RQ1: Which computer tools and/or methods are the *most used* in the creation of educational software for basic-education students with intellectual disabilities?
RQ2: Which computer tools and/or methods are the *most effective* for the creation of educational software for basic-education students with intellectual disabilities?
RQ3: What positive impacts are there on basic-education students with intellectual disabilities after the use of educational software?
RQ4: Which countries are the three best producers of scientific research on the topic of educational software?

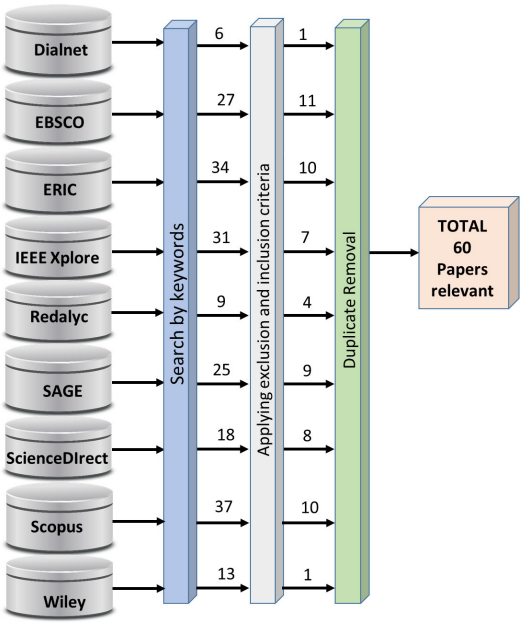

Fig. 1. Article recruitment process

2.4 Search strategies

To answer the research questions, a search of articles published in various databases, such as IEEE Xplore and Scopus, was carried out. In this regard, it is worth mentioning that a total of two hundred (200) scientific articles were collected and, after an exhaustive selection process, sixty (60) remained, being the most appropriate to the research topic, as shown in Figure 1.

The following string was used to search for articles: (special AND education) OR ("intellectual disabilities") OR ("intellectual disability") OR ("educational software") AND NOT animal.

2.5 Search strategies

For the systematic review study, criteria were applied to include and exclude articles to use only the most relevant ones. These criteria can be seen in the Table 1.

Table 1. Inclusion and exclusion criteria

Criteria		
Inclusion	I01	Articles related to educational software for elementary school students with intellectual disabilities
	I02	Articles with high or regular scientific evidence
	I03	Articles that apply a methodology, a model and/or a method in their development
	I04	Articles partially answering the research questions
	I05	Articles published in Spanish, English, or Portuguese
	I06	Articles published between 2016 and 2022

(Continued)

Table 1. Inclusion and exclusion criteria *(Continued)*

Criteria		
Exclusion	E01	Articles unrelated to education software for elementary school students with intellectual disabilities
	E02	Articles with little or no scientific evidence
	E03	Articles that do not apply a methodology, model and/or method in their development
	E04	Articles that do not partially answer the research questions
	E05	Unpublished articles in English, Spanish, or Portuguese
	E06	Unpublished articles between 2016 and 2022

3 RESULTS

Two hundred (200) articles related to the topic of the research were analyzed from the following databases, of which seventeen (17) duplicate articles were discarded. After reviewing the articles and deciding their eligibility, sixty-four (64) were excluded, since they did not contribute to answering the research question and the exclusion criteria.

Finally, after the selection process, the present research was left with sixty (60) articles for systematic review. Figure 2 shows the flowchart of the inclusion and exclusion process performed.

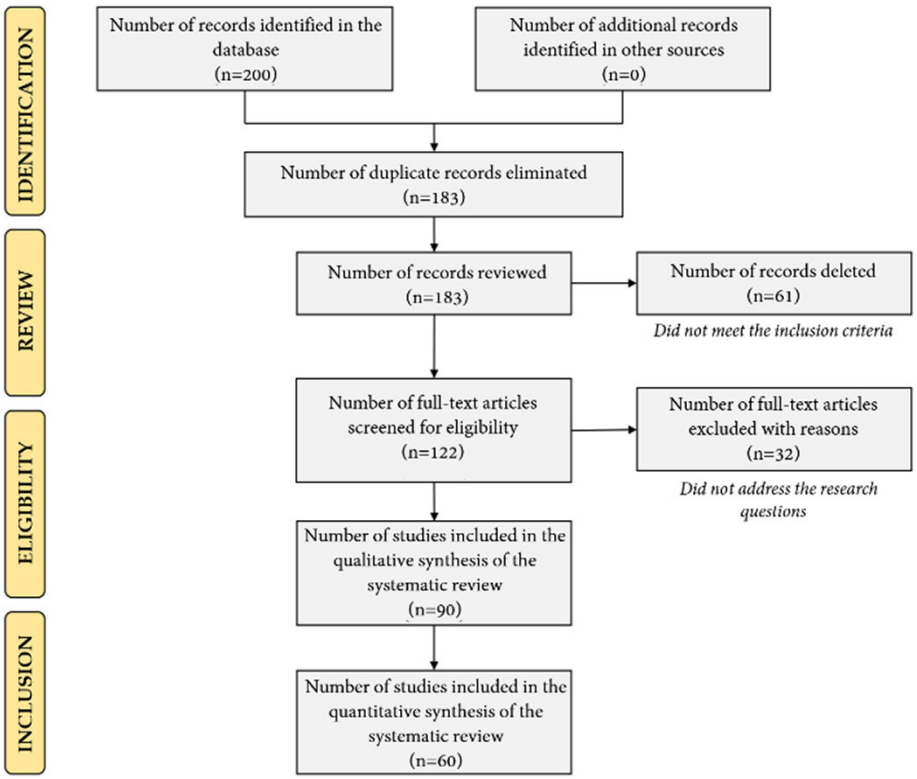

Fig. 2. PRISMA diagram methodology

Likewise, in this research work, it was also considered important to present the number of articles collected by section.

3.1 Articles by database

Figure 3 shows the number of articles collected per database.

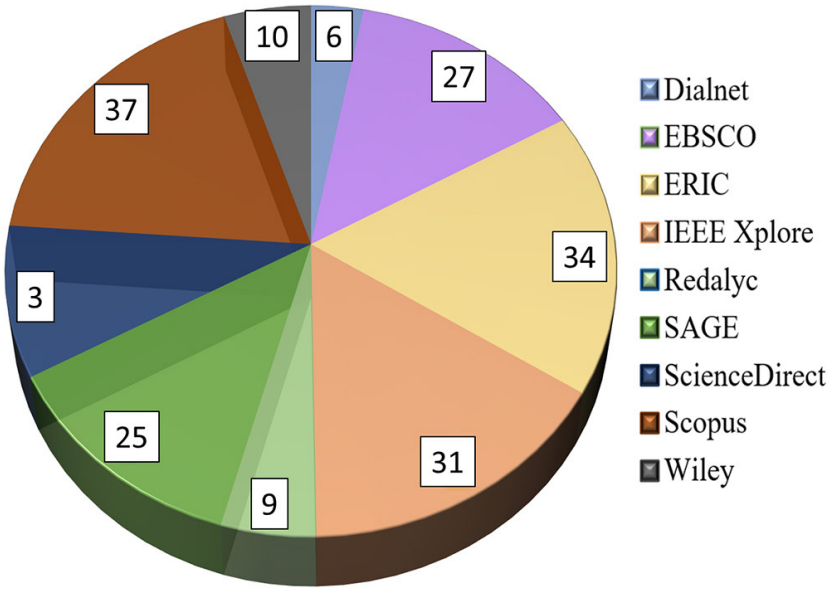

Fig. 3. Number of items collected by database

3.2 Articles by continent

Figure 4 shows the number of articles collected by continent.

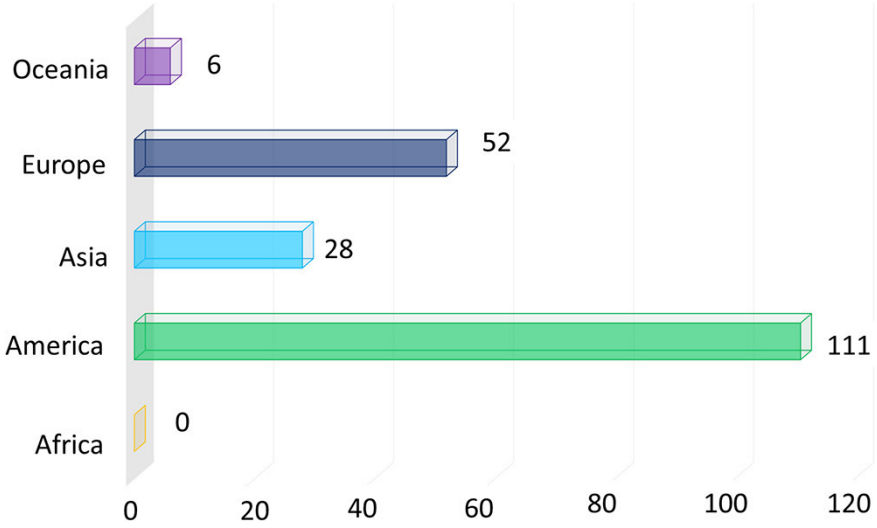

Fig. 4. Quantity of items collected by continent

3.3 Articles by country

Figure 5 shows the number of selected articles published by country.

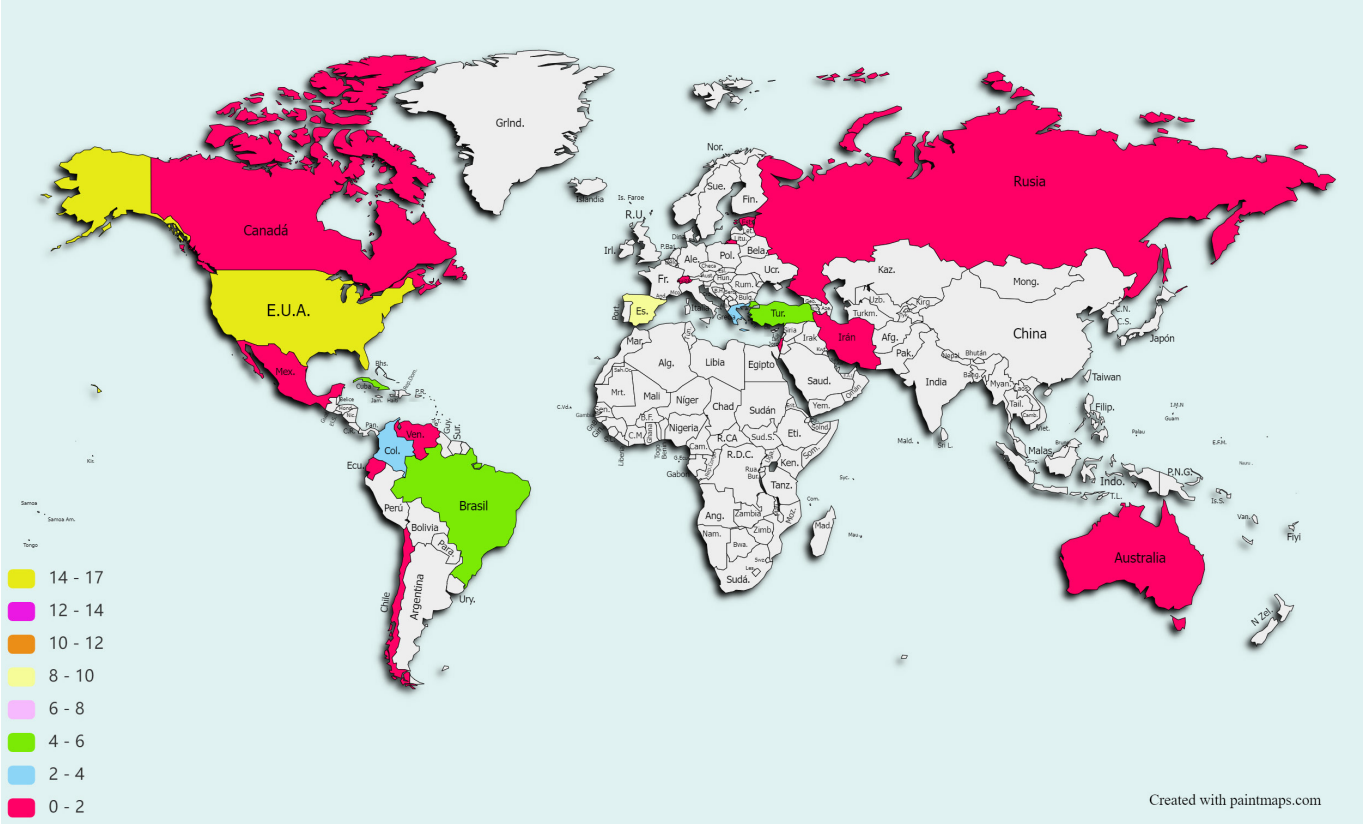

Fig. 5. Number of items selected for each country in the world

3.4 Articles by category and database

Figure 6 shows the number of articles grouped by category and database.

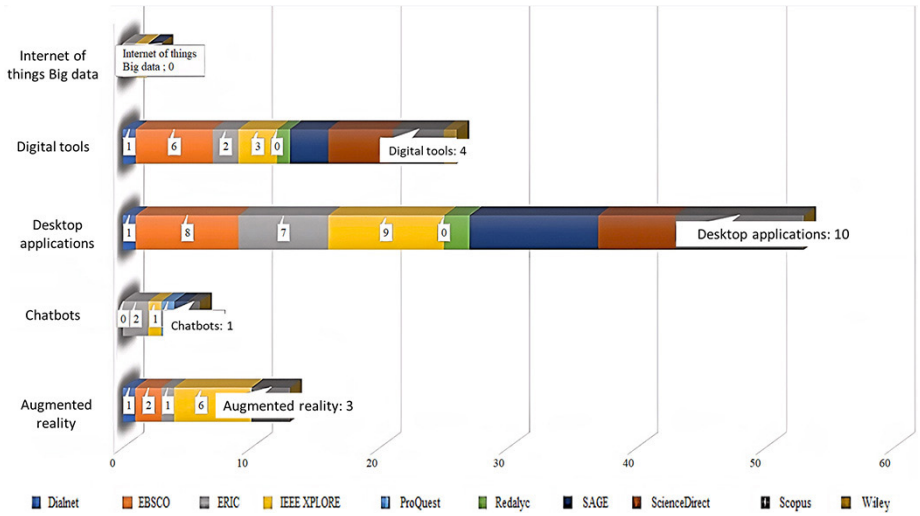

Fig. 6. Number of articles by category in relation to their source database

3.5 Articles by keywords

The VOSviewer tool was used for the visualization and analysis of concurrent results, for the construction of graphs based on all keywords as analysis, and for the identification of clusters and their networks, as Mendeley was used as the bibliographic manager.

VOSviewer [13] it provides text-mining capabilities that can be used to create and visualize matching networks of important terms excerpted from a large amount of scientific literature.

To identify all possible fields of study and variables associated with "Intellectual disability" and "Educational software, inclusive education, and interactive learning", we conducted a co-occurrence analysis with a minimum of 1-time occurrence per word, for each of the 297 keywords, in which the total strength of concurrent links to other keywords was calculated.

In this way, the variables are grouped by the keywords with the highest total link strength (Figure 7), where it can be seen that the numerous areas of intellectual disability and educational software with inclusive education and interactive learning are related to cooperative learning, technology, augmented reality, chatbots, mobile interface, Android platform, digital materials, special education, etc.

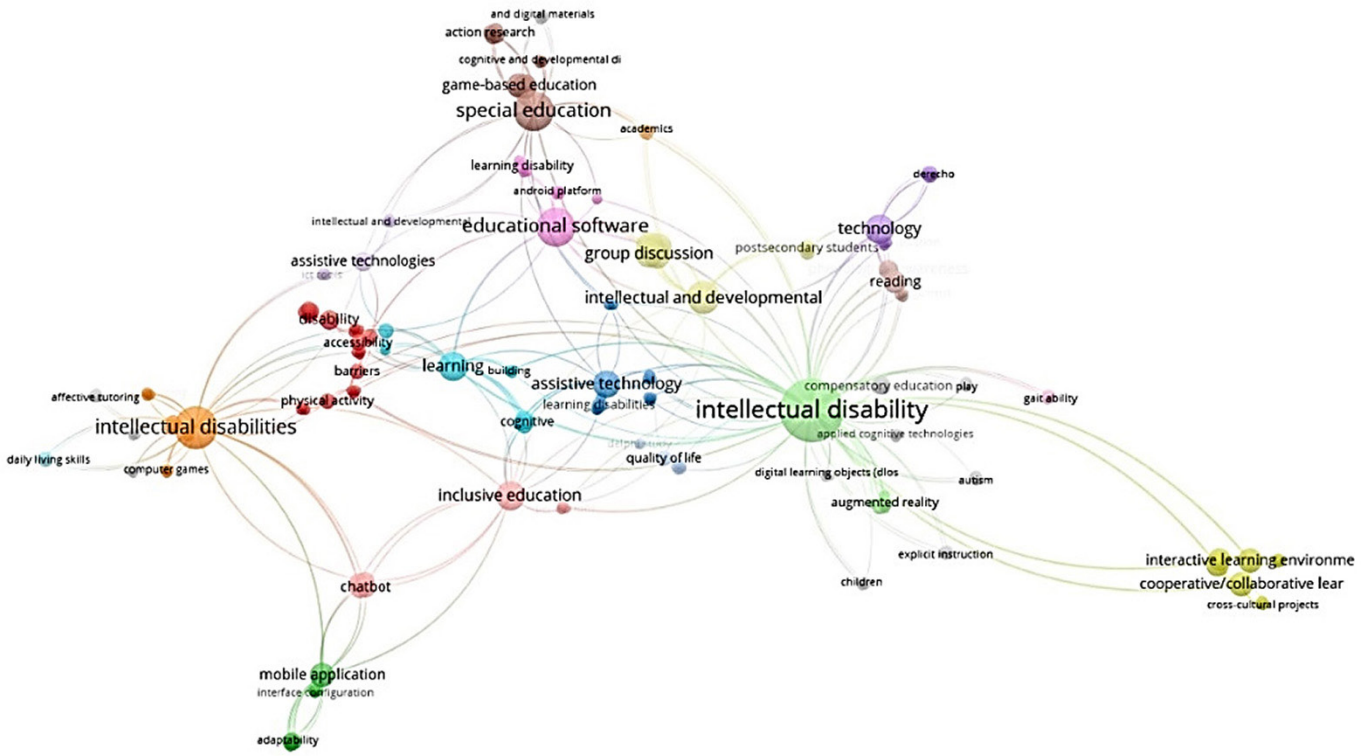

Fig. 7. Bibliometric visualization map of the most frequent common terms

- **Cluster 1 (Green):** Related to intellectual disability, where we find the main part of our search, containing applied cognitive technology, interactive learning environment, digital learning objects, and inclusive education.
- **Cluster 2 (Orange):** Related to disabilities, where a group of 10 items includes educational support, communication skills, and mobile learning.

- **Cluster 3 (Brown):** Related to special education, where another group of 10 items includes digital materials, action research, learning disabilities, and assisted learning tools.
- **Cluster 4 (Pink):** Related to educational software for students, where a third group of 10 items includes Android platform, learning disability, design, technologies, and intellectual and developmental.

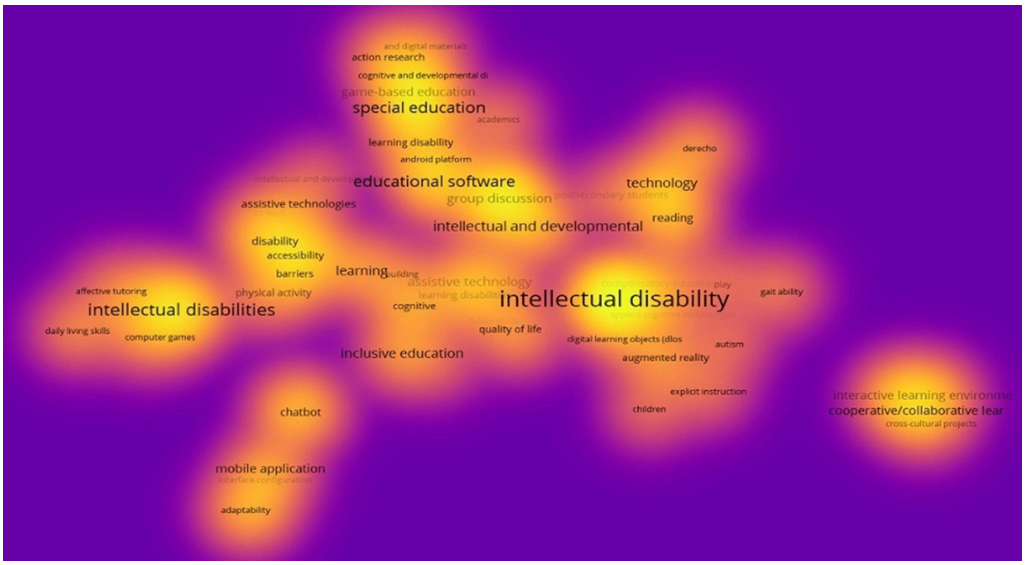

Fig. 8. Visualization of the density of the most frequent keywords

We also created bibliometric density maps for all the keywords obtained from the Mendeley database, with the colors of the different regions indicating their degree of correlation (Figure 8). The yellow areas represent the importance and concurrence of research related to the inclusion of Intellectual Disabilities and Educational Software with inclusive education and interactive learning. The other areas of lower density are shown as terms related to the main topics.

Fig. 9. Word cloud

Figure 9 shows the word cloud obtained from the keywords of the systematized articles, using R Studio software for this bibliometric analysis. The words “special education”, “disability”, “educational software”, among others, are highlighted.

Fig. 10. Tree map

Figure 10 shows the tree map with the percentages of the most recurrent words such as “intellectual disability”, “special education”, among others.

Table 2 shows the items within their respective categories.

Table 2. Classification of articles according to the results obtained

Category	Articles
Mobile applications	[14], [15], [16], [17], [18], [19], [20], [21], [22], [23]
Augmented reality	[24], [25], [26], [27], [28], [29]
Digital tools	[30], [31], [32], [33]
Web applications	[34], [35], [36], [37], [38], [39], [40], [41], [42]
Desktop applications	[43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59]
Internet of things. Big data	[60]
Chatbots	[61], [62]

Table 3 shows the details of the functionality and theme according to each selected item.

Table 3. Functionality according to classification theme

Themes and Functionality	References
These articles argue that mobile applications help young people with intellectual disabilities, showing the applications' potential educational value and ability to facilitate communication in everyday life.	[14], [15], [16], [17], [18], [19], [20], [21], [22]
These articles argue that augmented reality can help the learning process of students by providing digital technologies that can contribute to their education.	[24], [25], [26], [27], [28], [29]
These articles argue that the use of mobile applications and web applications to improve students' communication and language skills is a great help in their work.	[30], [31], [32], [33]
These articles argue that the use of educational software aims to improve teaching processes and blended learning in different types of schools.	[34], [35], [36], [37], [38], [39], [40], [41], [42]
These articles argue that the usability of digital technologies increases learning competencies in students where the interaction of the student with different applications is seen.	[43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59]
These articles argue that automatic learning with didactic materials can enhance learning in children with intellectual disabilities.	[60], [63],
This article argues that the use of a mobile application with a web service allows the frequent interaction of teachers to upload didactic materials where they provide different types of documents for the support of people with intellectual disabilities.	[60]
These articles argue that the use of a technical platform helps English-speaking students with intellectual disabilities learn in a simpler and more dynamic way, resulting in a good impact on learning.	[60], [64]
This article argues that the use of chatbots as an educational tool allows accessibility for people with intellectual disabilities and facilitates the learning of social skills as it allows them to maintain a conversation automatically.	[61]
These articles argue that the use of literacy software allows teachers to create their own tools for students with intellectual disabilities to meet their individual needs.	[65], [66], [67], [68], [69]

Table 4. Classification of articles according to category and programming language employed

Category	Programming Language	References
Mobile applications	WCAG/MWBP	[14], [15], [16]
	JAVA SCRIPT	[20]
	ANDROID STUDIO	[21]
Augmented reality	C#	[26], [27]
	UNITY	[28], [29]
Digital tools	PHP	[30]
	UNITY	[32], [33]
	HTML	[31]
Web applications	PHP	[39], [40], [41]
Desktop applications	HTML	[43], [44], [45]
	UNITY	[46]
	PHP	[47], [48]
	HTML CSS3	[49], [50]
	ACTION SCRIPT	[51], [52], [53]
Chatbots	IBM CLOUD	[61]
	WATSON ASSISTANT	

Table 5. Classification of articles according to category and database engine

Category	Database Engine	References
Mobile applications	MONGO DB	[14], [15], [16]
Augmented reality	MYSQL	[26]
	VISUAL STUDIO	[27]
	CSS	[28], [29]
Digital tools	MYSQL	[30]
	POSTGRESQL	[32], [33]
	ACCESS	[31]
	TINYMCE	
Web applications	SUBLIME TEXT	[41]
Desktop applications	CSS	[47], [48]
	MARIADB	[49], [50]
	VISUAL STUDIO	[51]
	ORACLE	[52], [53]
Chatbots	IBM DB2	[61]

Table 6. Classification of articles according to development environment used

Category	Development Environment Used	References
Mobile applications	AAC	[30]
	GITHUB	[32]
Augmented reality	UNITY	[24]
	VIRTUAL	[25]
	STUDIO	[26]
Web applications	HTML – CSS	[31], [32]
Digital tools	FRAMEWORK	[34], [35]
	LARAVEL	[37]
	JAVA SCRIPT	[42]
Desktop applications	JAVA SCRIPT	[43], [44], [45]
	SPSS	[47], [48]
	GITHUB	[58], [59]
Internet of things Big data	PSD / PID	[60]
Chatbots	WATSON	[65], [66]

4 DISCUSSION

4.1 Research questions

RQ1: Which computer tools are the most used in the creation of educational software for basic education students with intellectual disabilities? To begin with, we chose to elaborate on Table 2 to show which were the most salient categories identified in the systematic review. In this regard, the three categories that stand out correspond to mobile applications, desktop applications, and web applications. Based on this, Table 4 was prepared to show which were the most outstanding tools in each category. In this regard, the tools used were subdivided into programming language, development environments, and database engine (Tables 4–6). In the same way, it was found that the programming languages that stood out were PHP and C. Likewise, the leading development environments were Visual C++ and NetBeans. Finally, the database engines were MySQL and SQLite.

RQ2: Which computer tools are the most effective for the creation of educational software for basic-education students with intellectual disabilities? To answer this question, we decided to see which articles indicated the most benefits (i.e., relevant articles) in their results. In other words, the more benefits obtained, the more effective the IT tools were. In this regard, we found that the most effective programming language is C. Likewise, the most effective development environment is NetBeans. Finally, the most effective database engine is MySQL.

RQ3: What positive impacts are there on basic-education students with intellectual disabilities after the use of educational software? According to Tables 3 and 6, it can be observed that there are multiple benefits obtained, as explained in each article. In this regard, it was highlighted that the most recurrent ones are the students' better attention capture, the favoring of autonomous learning, and the ease of knowledge acquisition.

RQ4: Which countries are the three best producers of scientific research on the topic of educational software? In this regard, we can see that, according to Figure 5, the United States and Spain are the countries with the highest scientific production on the topic in question. As can be seen, the United States leads with 17 scientific productions identified in this literature review, followed by Spain with 9 investigations.

4.2 Related work

In a systematic review [70] analyzing the use of portable mobile devices for teaching people with intellectual disabilities—mainly autism and developmental disabilities—18 articles were systematized, identifying the contributions in the development of skills related to home, school, community, and work. The article [71] systematized 228 documents, analyzing academic instruction for students with significant disabilities, primarily reading skills. The study determined that interventions allow for progress in targeted academic skills. Based on the universal design of learning for students with intellectual disabilities, the systematic literature review [72] concludes that digital environments, e-books, software, and audio systems confirm the efficacy of these interventions in academic, social, and behavioral aspects.

4.3 Proposed model

Considering the results obtained from the tables, a model is proposed to evaluate the tools that allow the development of educational software. The pedagogical, technical, and technological aspects were considered, the latter referring to the area of technology and information technology that is composed of a series of characteristics, each with specific indicators, which consider the necessary elements for a good selection. These three aspects were taken into account because of their relevance and their educational interest, and because they make explicit the requirements of the areas of technology and informatics. Figure 11 shows the conceptual map of the proposed design for future implementation.

- **Pedagogical aspects:** The benefits, the content, and the level of interaction provided by the tool are evaluated.
- **Technical aspects:** The installation, navigation, design, and reliability of the tool are evaluated.
- **Technological aspects:** The features, indicators, and functions provided by the tool are evaluated.

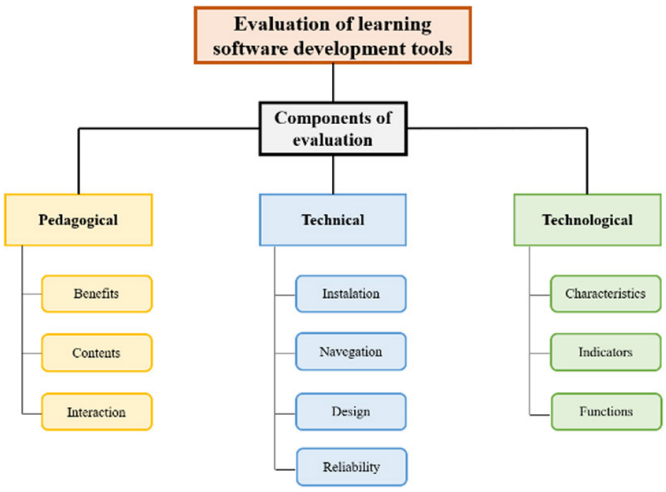

Fig. 11. Proposed model of evaluation of tools for developing educational software

5 CONCLUSIONS

The application of educational software in the teaching of students with intellectual disabilities is a largely unexplored topic, because little research has been done that covers all three keyword terms (educational software, student with intellectual disabilities, and basic education). However, after our research, we conclude that it is very important because it facilitates the development of educational activities the student, as well as the resources to develop such activities.

Educational software is also very important in distance education. Many of these technological tools allow simulating the conditions that exist in a classroom, so the student can enter a virtual classroom, interact with the teacher through videoconferences, chat, or e-mail, complete evaluations, etc.

Given the importance of educational software as a mediator of the teaching-learning process, it is necessary to have a model for the selection of this type of material. In this sense, we propose a model that considers the quality standards for the selection of educational software suitable for the area of technology and computer science. Thus, the teacher will be able to select material close to the nature of the educational activity.

Finally, future work to carry out software development projects should consider knowledge from other branches of computer science. Considering which computer tools and/or methods are the most effective and putting them together with other categories such as Big Data could lead to better results and further improve the education of students with intellectual disabilities.

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7 AUTHORS

Alfredo Leonidas Vasquez Ubaldo is a computer and systems engineer. He has skills and knowledge in information systems development, modeling, and database administration. He also has high-level experience in IT service management (email: a2020101884@uwiener.edu.pe).

Vanessa Yeny Gutierrez Barreto is a computer and systems engineer. She has skills and knowledge in information systems development, modeling, and database administration. She also has high-level experience in video game development (email: a2020103396@uwiener.edu.pe).

Fernando Sierra-Liñan is Professor of Research Methodology at the Universidad Privada del Norte. His degrees include a Masters in Education with mention in Edumatics and University Teaching from the Technological University of Peru and degrees in Education with a mention in Science and Technology from the Universidad San Ignacio de Loyola and in Systems and Computer Engineering from the Technological University of Peru (email: fernando.sierra@upn.edu.pe).

Michael Cabanillas-Carbonell is a qualified researcher at the National Council of Science, Technology and Innovation – Peru. He is a Research Professor at Norbert Wiener University, a PhD candidate in Telecommunications at the Polytechnic University of Madrid, President of the IEEE-Peru Education Society Chapter, and Conference Chair EIRCON (Engineering International Research Conference) (email: mcabanillas@ieee.org).