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# Language learning apps for visually impaired users: a systematic review

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## Abstract

The purpose of this literature review is to identify, categorize, and critically appraise research papers related to mobile apps for visually impaired people in language learning. This study intended to identify the language skills, the affordances, and the limitations encountered while designing and implementing the apps. Hence, a systematic review in the Scopus database and the virtual libraries of IEEE, SAGE, ERIC, and Science Direct, adhering to the PRISMA methodology, produced 274 research papers, and after the application of the different phases, a detailed analysis was performed using 17 articles. The results revealed that Information Communication Technologies, assistive technologies, and electronic accessibility features contributed to the usability guidelines and the current evolution toward modern language learning mobile applications for visually impaired users. The revised work also revealed how writing, reading, and spelling became more demanding for this particular special need, and that grammar-based and traditional activities are replaced by other communicative approaches. The emphasis was on speaking and listening skills due to these being less demanding in terms of technical requirements. The findings of this review provide insights for instructional designers to construct inclusive language learning apps which consider the three essential dimensions needed to achieve it: technological, pedagogical and psychological, in addition to appropriate affordances necessary for both sighted and visually impaired users.

**Keywords:** Visual impairment, Language learning, Assistive technology, Mobile assisted language learning, Affordances

## Introduction

Technology has transformed teaching methodologies in almost all areas (Aguiar-Castillo et al., 2021). Every day, information and communication technologies (ICT) are becoming increasingly relevant to global educational systems (Abel et al., 2022; Mircea et al., 2021). Modern generations interact with technology very quickly, and the challenges for teachers



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increase steadily (Rahmatullah et al., 2022). University professors must be prepared to use digital tools (Aditya, 2021; Beardsley et al., 2021) and be willing to provide students with innovative content according to their future needs (Ramírez-Montoya et al., 2021). In response to such challenges, mobile learning has been increasingly implemented in education (Bond et al., 2019; Chen & Tsai, 2021). It is considered a separate field from e-learning research and practice, and for example, it has been relevant in technology-based approaches to enhance informal language learning among migrants (Viberg et al., 2021).

Several other benefits have also been established through Mobile Assisted Language Learning (MALL), such as learning independently of time and place, high motivation and interest, time and energy saving, individualized learning, collaborative learning, autonomous learning, and learning to enjoy. It also allows creating authentic tasks, scaffolding interaction with others, presenting both visual and verbal information and providing learners the choice of modality (Chen et al., 2020; Dağdeler & Demiröz, 2022; Joseph & Uther, 2009). MALL has also emerged as a response to all of the various needs in terms of time, ubiquity, emergencies, and disabilities encountered. Today, it is becoming more common to assist Visually Impaired Users (VIU) utilizing mobile devices. However, this approach remains under-evaluated. A crucial component of efforts to enhance inclusion, participation, and diversity in education is accessibility, which is becoming an increasingly important feature in the delivery of learning and training (Byrne, 2022; Kuriakose et al., 2022; Martiniello et al., 2022).

Systematic reviews (SR) related to VIU, mobile learning, assistive technologies, and education have focused on specific concerns and gaps previously identified. However, none have revised language learning apps in terms of skills, affordances, and limitations yet. Within the last five years, there have been the following relevant reviews regarding assessment, usability, software accessibility, English learning, and technologies. For example, Table 1 shows the studies by Donmez (2023), Hoskin et al. (2022), Leria et al. (2021), Miyauchi (2020) and Schultz and Savaiano (2022), focused on the inclusive education of students with visual impairment, the teacher's perceptions, the use of current technology for braille literacy education, emphasis on aural–oral skills, and teachers' influence on students' performance. Those studies consider visual disability as an opportunity for motivation and engagement with technology.

However, what has the literature said between 2019 and 2023 and what do various relevant studies provide on the subject? To respond to this concern, we believe it is important to synthesize what various articles provide, using PRISMA as a rigorous and transparent method (Page et al., 2021a).

**Table 1** Previous related systematic reviews

Authors	Year	Title	Research question	Keywords / Focus
Schultz & Savaiano	2022	English language learners with visual impairments: An exploratory literature review	What is the existing literature specifically examining English language learners with visual impairments (ELLVIs)?	English Language Learn, ELL, ESL, dual language, minority language learns, ESOL, bilingual, Limited English Proficient, LEP, low vision, blind, blinding or blinded
Hoskin et al.	2022	Effectiveness of technology for braille literacy education for children: a systematic review	What is the effectiveness of technology applied within braille literacy education for children and youth?	braille, child, youth, education, technology
Donmez	2023	A systematic literature review for the use of eye-tracking in special education	<ol style="list-style-type: none"> <li>1. What is the usage and potential of eye-tracking to facilitate the education of students with special needs?</li> <li>2. What are the disabilities that eye-tracking technology was previously utilized in special education?</li> <li>3. What is the relationship between learning outcomes and eye-tracking measurements in special education research?</li> </ol>	education, learning, special education, gifted education, special needs, disability, low vision, visually impaired, eye-tracking, eye movements, gaze tracking, and gaze movements
Leria et al.	2021	Assistive technology in large-scale assessments for students with visual impairments: A systematic review and recommendations based on the Brazilian reality	How are researchers and professionals using technology solutions with digital accessibility in large-scale educational assessments to allow students with visual impairments to take these tests with autonomy?	visual disability, blind, visual impairment, low vision, accessibility, accommodation, usability, digital accessibility, assistive technology, accessibility tool, computer based assessment, computer-based test, inclusive assessment
Miyauchi	2020	A systematic review on inclusive education of students with visual impairment	What are the perceptions of general education teachers and challenges faced by students with visual impairment in accessing academic subjects?	visually impaired, visual impairment, low vision, blind, inclusive education, inclusion, mainstreaming, integration, academic achievement, academic performance, academic success, social skills, social interaction, social behavior, social competence

## **Visual impairment**

Historically, protecting the rights of people with disabilities has been a slow process. Laws still discriminate against people with disabilities, often mental disabilities, in education, voting, and the provision of benefits and licenses. Fortunately, laws like the ADA (the Americans with Disabilities Act) in the U.S. have shown that people with disabilities can and should be full members of society. However, more significant judicial consideration is required to defeat stigma and perceptions (Waterstone, 2014). As education is a fundamental right for all granted in the Declaration of Human Rights, governments and laws must help address one of the dominant problems in the disability field: the lack of access to language learning from which VIU suffer.

Guaranteeing accessibility is a pending task that distance education developers have not yet fulfilled since minorities seem not to be a priority. Notwithstanding, the World Health Organization estimates that 2.2 billion people have some type of visual impairment and classifies vision impairment into two groups, distance and near presenting vision impairment: Mild, moderate, severe, blindness, near vision impairment (2022) which encourages researchers to reflect on the need for online environments and the adaptation process needed by people struggling to access education and the internet in general.

## **Assistive technology and mobile assisted language learning (MALL)**

Assistive technology aims to help students with learning difficulties and those regular students who have not received proper comprehension strategies (Özbek & Ergül, 2022). In mastering a foreign language for students with disabilities, mobile learning can also be seen as a chance to improve some teaching and learning practices since it offers more networking sites that are inclusive and user-friendly (Svalina & Ivic, 2020). Furthermore, providing clear instructions is not enough to enhance the understanding of students with learning disabilities, as the contextualization of instructions is also required (Miller, 2016). These contextualized instructions can occur through the use of proper building vocabulary, proper building background, and providing vast opportunities to practice and apply new knowledge (Miller, 2016). Similarly, Lo et al. (2017) described explicit computer-assisted morphology instructions as a pedagogical manner to support English learners with reading disabilities in acquiring adequate competencies and language proficiency.

Using information technology in inclusion processes can enhance the independence and autonomy of VIU. There is evidence that the use of digital technology, such as computers, laptops, and mobile devices, has changed the lives of youngsters and as a response to special needs encountered, assistive technology has been applied to the education of students with visual impairment; however, teachers indicate the need for infrastructure and pedagogical support, as well as more empirical studies on this matter. Providing access to educational materials and increasing employment prospects for VIU are seen as some of

the principal benefits of assistive technology (Alkhaldeh & Khasawneh, 2021; Cranmer, 2020; Kisanga & Kisanga, 2022).

### **Visual impairment and MALL**

Language learning frequently uses mobile pedagogy to foster real-world communication (Norris & Kukulska-Hulme, 2017). To advance its educational strategies, it needs sustainable development in design, assessment, and practice as well as expertise in faculty coaching and scaffolding (Martin et al., 2019). All MALL benefits seem suitable to a wide range of learners, including VIU, but it is necessary to raise awareness about the implications. To characterize linked domains, including policymakers, institutions, teachers, and students, six components are highlighted: technology, policy, pedagogy, student, online resources, and mobile devices (Zhang & Yu, 2022). Similarly, the factors related to the adoption of mobile learning in higher education such as trust, characters and personal qualities, context, perceived usefulness of using, behavioral intention, and culture are also considered (Hamidi & Chavoshi, 2018). Since visual impairment demands clear policies of accessibility over the factors mentioned, Mishra et al. (2018), have suggested an environment descriptor to give natural language descriptions of images. Tsai et al. (2019) suggested the indoor special voice navigation to ensure quality and effectiveness for those with and without visual impairments, and earcons are described by McGookin (2020) as abstract tones blended to form aural messages and represent events like someone entering or departing a virtual place. As mobile touchscreen technology has developed in sophistication, different users might receive significant benefits regarding their special needs.

In this sense, several functionalities and features can be summarized in (1) screen reader, (2) speech recognition, (3) switch access (i.e., facilitating interaction with mobile devices without touching the screen), (4) captioning and audio descriptions, (5) screen magnification and zooming options, (6) support of different color modes, (7) color correction for color blindness, (8), mono audio, sound, and volume controls for adjusting auditory output, (9) color contrast controls, (10) haptic keyboard (e.g., Braille soft keyboard in iOS 8 and later), (11) a variety of visual, auditory or vibrational notification options, (12) touch and hold delay options, (13) auto-complete text settings, (14) gesture settings and customization, and (15) screen orientation controls (Alajarmeh, 2022).

As touch screens are now pervasive, accessing information is a major challenge for blind users. From the list of features, it is important to outline that it is common to find text entry solutions for users who are VIU that can be classified into non-Braille-based approaches and Braille-based approaches. Non-Braille-based approaches utilize standard virtual keyboards with a screen reader, voice commands, gestures, or thumb strokes. In contrast, Braille-based approaches are based on gestural interaction using both hands or one hand,

along with different forms of feedback (Alajarmeh, 2022). For example, Finger Based Techniques such as Single Digit Finger-Digit Input and Double-Digit Input are based on the use of virtual keys utilizing finger-holding positions that follow voice feedback while enabling touch, as in the input gesture (Fakrudeen et al., 2014). Since there are several affordances and features related to accessibility, it is necessary to organize assessment criteria under formal parameters to explore how to use mobile technology effectively to support language learning involving visual impairment. This variety requires a formal assessment criteria framework to determine how to use mobile technology to support language learning and visual impairments continuously.

In order to appreciate the value of mobile learning while building and deploying learning-focused apps, some have advocated the following affordances of mobile learning: they are suitable in numerous contexts, they are portable and provide the user with ubiquitous access to learning, they enable instantaneous or asynchronous social interactions, they provide real-time information delivery to users, and incorporate note-taking, images, audio, and video recording, in addition to books, encyclopedias, simulations, and worksheets all being examples of content interactions. Furthermore, real-time data is available to mobile learners (Danish & Hmelo-Silver, 2020; Hwang et al., 2021; Pishtari & Rodríguez-Triana, 2022). Likewise, under the heading of restrictions, which is regarded as the absence of something pertinent for the pedagogical process, the flaws inherently present in MALL as well as other non-viable aspects are also taken into consideration for this research topic. Limitations might be classified as psychological (motivation and emotion), pedagogical (a lack of performance support model to monitor feedback and struggles with connectivity), and technical (difficulties with printing, resolution, screen adaptations) (Sophonhiranrak & Sakonnak, 2017; Wang & Higgins, 2005).

Faced with the reality of technological implementations for students with visual impairment to learn a language, we carried out an up-to-date systematic review of 2019–2023 research articles involving mobile apps oriented towards the VIU in the field of language learning. The goal was to identify, categorize and critically evaluate different research works, specifically the language skills addressed, and the possibilities and limitations encountered when designing and implementing the applications. The research questions were:

- (1) What are the methodological designs employed in MALL apps aimed at language learning and students with visual impairment?
- (2) What are the language skills addressed in MALL apps aimed at language learning for students with visual impairment?
- (3) What are the affordances and limitations encountered while designing and implementing MALL apps aimed at language learning for students with visual impairment?

## Method

### Dataset

To answer the research questions, the Preferred Reporting Items for SR and Meta-Analyses for Systematic Reviews Protocols (PRISMA-P) (Moher et al., 2015; Shamseer et al., 2015) was completed in September 2022. PRISMA was elaborated by a group of methodologists and journal editors in 2009, in order to improve the clarity, transparency, quality, and value of systematic reports (Page et al., 2021; Hutton et al., 2016). Authors such as Urrútia and Bonfill (2010) state that PRISMA represents a way to guarantee the validation of sources; in other words, to analyze “objectively and systematically the results of empirical studies on a given research problem” (Sánchez-Meca, 2010, p. 53). Additionally, PRISMA responds to the need to synthesize in a practical way the most relevant information revealed with the increase of scientific works (Pérez, 2012).

Several inclusion/exclusion criteria were considered and the design and procedure established by this documentary research methodology was followed (Page et al., 2021a, 2021b, 2021c; Hutton et al., 2016). Additionally, different systematic studies recently conducted in the field of educational research, technologies and disabilities were taken as a reference (Alemdag, 2023; Crosthwaite et al., 2022; Kaushik & Verma, 2020; Molero-Aranda et al., 2021; Rosli et al., 2022; Sola et al., 2018; Vieira et al., 2018; Viñoles-Cosentino et al., 2022).

These steps facilitated the development of the SR. It is relevant to state that this SR was carried out collaboratively, with several researchers reviewing all the references found as a group, and individually, in order to minimize possible biases produced by previously held opinions of the team members regarding the topic.

Likewise, it was established that documents with discrepancies would be subsequently analyzed in greater depth. However, there were no cases in which agreement was not reached on the interpretation and analysis as the consensus among researchers was established with the inclusion or exclusion of references (Gisbert & Bonfill, 2004).

The protocol that led to the SR process began with the definition of the research questions, the establishment of the inclusion/exclusion criteria, the strategies implemented for the search of sources, and the analysis and evaluation of the studies' quality. These steps are described below.

### Inclusion and exclusion criteria

Every SR implies the application of a series of inclusion/exclusion criteria for the selection of the studies to be analyzed. Therefore, taking into consideration the topic of this study from 2019 to 2023, we limited that data range inclusively since authors (Nahar et al., 2015; Paisios et al., 2012) developed different prototypes to respond to the mobile learning needs

**Table 2** Inclusion /exclusion criteria

Inclusion criteria	Exclusion criteria
Must be research articles and proceedings published in peer-reviewed indexed journals available through the Universidad del Norte database system from 2019 to 2023.	Systematic review articles, or literature review articles, reviews, chapters of books, dissertations, or reflection papers.
Must be available research articles published on the Scopus database and virtual libraries such as IEEE, SAGE, ERIC, Science Direct.	Research articles that are not available in peer-reviewed indexed journals or that are not available through the Universidad del Norte database system or reliable databases and virtual libraries, published before 2019.
Must be published in the following languages which our team members could read and understand English.	Research articles published in languages other than English.
Must be research articles focused on Mobile Assisted Language Learning and students with disabilities.	Research articles that are not focused on Mobile Assisted Language Learning and students with disabilities.
Must be research articles and proceedings focused on Mobile Assisted Language Learning and students with visual impairment.	Research articles and proceedings that are not focused on Mobile Assisted Language Learning and students with visual impairment.

of VIU. These proposals have become a new trend in inclusive education at different levels in which m-Braille and Braille touch for android and iOS systems have emerged. Besides, they have promoted a new perspective on touch-based devices in the last decade and continue expanding rapidly today.

### Literature-searching strategies

To obtain the corpus, the first step was to determine the sources of consultation for conducting the SR. For this purpose, five databases were selected in the areas of Social Sciences, Education, and Technology. From the SIBILA+ access system, access was gained to the Scopus database and to the most widely used virtual libraries such as IEEE, SAGE, ERIC and Science Direct. This facilitated the searches performed in these databases relevant to the topic.

The next step to achieve a refined and ethical search, one which guarantees its validity and traceability, was a careful consideration - as part of the criteria of the PRISMA statement (Urrútia & Bonfill, 2010) - of the keywords with which each search was initiated. The search string used was:

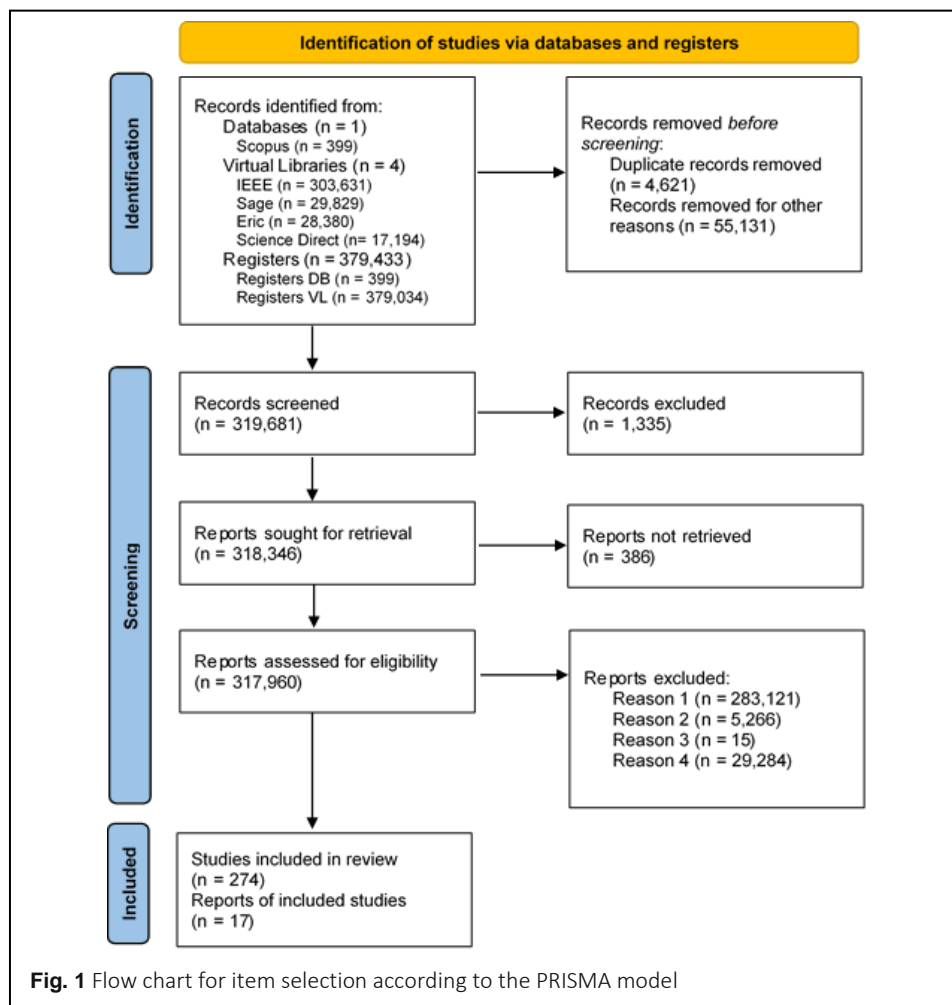
“(((mobile applications) OR (mobile technology) OR (apps) OR (mobile learning) OR (assistive technology) OR (smartphones) OR (technology)) AND ((language learning) OR (English learning)) AND ((visual impairment) OR (visual disability) OR (blindness)))”.

The research team was assisted by a university librarian who provided meaningful guidance in the creation of the search strings. The keywords were selected following a close examination of related literature, and discussion among the authors. It is worth



mentioning that one of the authors of the research team is visually impaired, and they provided recommendations to identify and select the appropriate terms for the search.

After carrying out an extensive search, a total of 379,433 articles were found in the four databases. Based on the identification step, the 379,433 were reduced after the exclusion and inclusion criteria found in Table 1 were applied. The different searches resulted in a considerable number of diverse documents (317,960 from 2019 to 2023), from which 317,686 were eliminated for not including all the search terms and repeated ones. These were filtered to leave 274 articles that were downloaded in the Zotero document manager, and transferred to a shared database on OneDrive ([Total records 274.xlsx](#)). Those articles were screened by title, abstract, and keywords with the purpose of identifying the research papers matching our research questions, where they had to mention the use of MALL to teach languages to students with visual impairments or other disabilities. Figure 1 shows the flow chart detailing the phases followed during the document selection process. The diagram was created using Shiny app for producing PRISMA 2020-compliant flow diagrams of Haddaway et al. (2022).



Afterwards, the reading in the screening phase facilitated the review of the titles and abstracts by five researchers, applying the previously agreed inclusion and exclusion criteria. Exclusions occurred for several reasons; for instance, some articles only described the design and development of an app, others were proceedings or addressed the design of an app for students with visual impairment, but were not for language learning; lastly, some articles described students' perspectives and attitudes towards the use of MALL for language learning but were unrelated to the research purpose of this SR. After this review, 257 records were eliminated for not responding to our research questions about language skills, methodology and affordances and limitations. Finally, 17 articles ([Records included 17.xlsx](#)) were selected from this analysis, since it was found that all were related to the research questions formulated in this SR. These articles were found to be published in 12 journals indexed in the Scopus database, and the virtual libraries of Springer, SAGE, Taylor & Francis, and EBSCOhost. In relation to the Scimago Journal & Country Rank (SJR), these 12 journals are classified according to quartile, for example, 3 are Q1, 3 are Q2, 4 are Q3 and 1 is Q4. One of these journals (English Language Teaching) is currently not assigned the quartile system, though it is included in virtual libraries such as ERIC and EBSCOhost (see Appendix).

To facilitate the analysis of the data from the bibliographic search with PRISMA, technological tools such as EXCEL and PowerBI were used. Similarly, VOSViewer was used to construct and visualize bibliometric networks, for example, of co-occurrence of keywords extracted from the literature review.

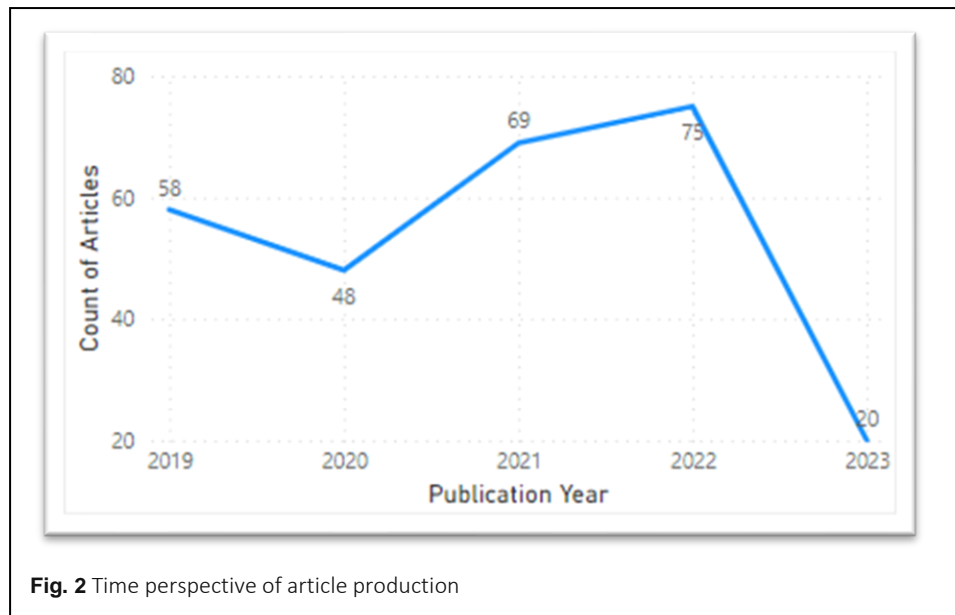
## Results

This section presents the article metadata and findings in relation to the research questions.

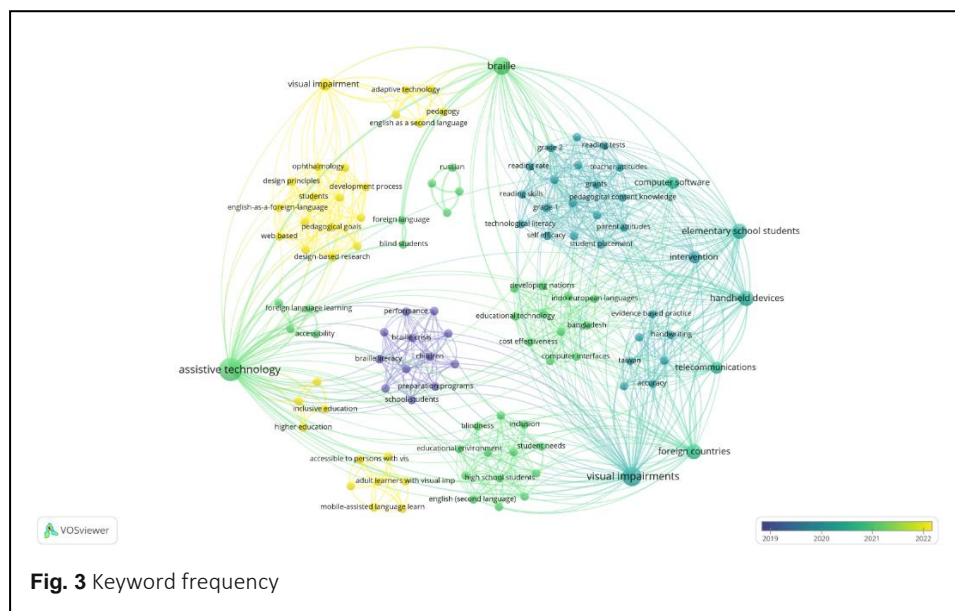
### Article metadata

These findings help answer the questions that guided this SR. For example, a temporal perspective is drawn in the timeline shown in Figure 2, where the distribution with the highest concentration of production in the last two years (2020 and 2022) is observed. This might be the result of COVID-19 emergency remote learning necessities that arose during the pandemic. On the other hand, since 2022 until now (2023), the publication trend of articles related to MALL and Visual Impairment plummeted to less than half (26%) of 2022 publications.

Another finding is related to the keywords found in the articles, defined through the frequency of keywords that most occur across the articles. This data shows which are the investigations that most study the subject of the design and implementation of mobile applications for language learning.



**Fig. 2** Time perspective of article production



**Fig. 3** Keyword frequency

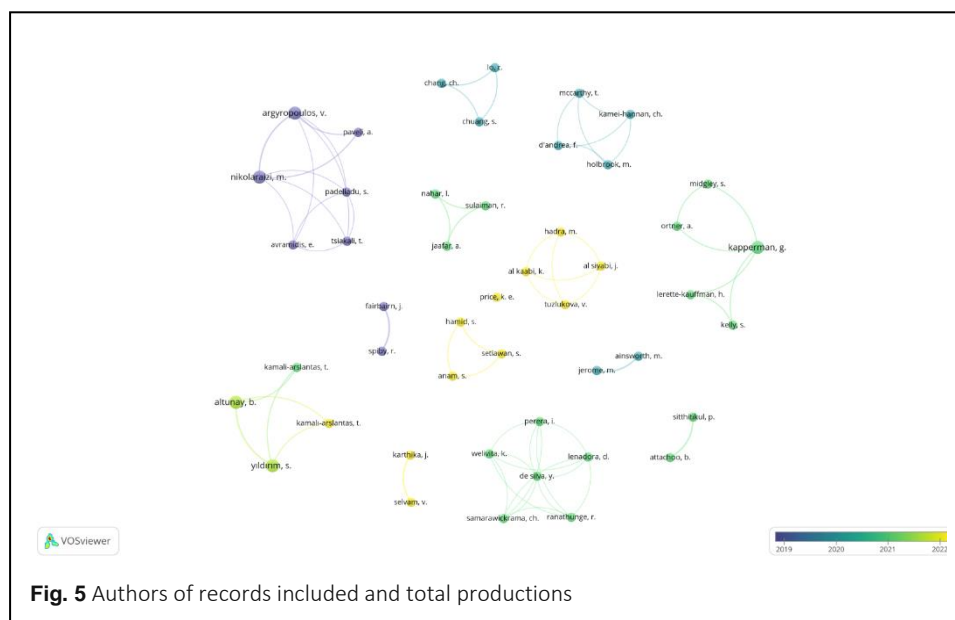
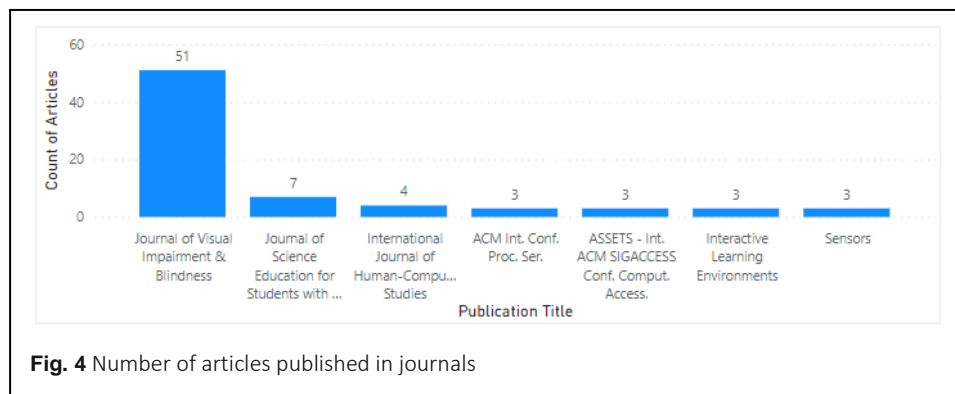
Figure 3 shows that the representative terms, organized from highest to lowest frequency, are distributed in 9 large groups: “assistive technology”, “visual impairment”, “visual impairments”, “braille”, “computer software”, “foreign language learning”, “accessibility”, “school students” and “handheld devices” (<https://tinyurl.com/2cgzegwu>). However, the most frequent nodes are the first three. All are connected to more specific items according to the topic.

The color visualization is determined by the publication years, where by default colors range from purple (2019) to green to yellow (2022-2023). Green nodes indicate a major

impact on this paper focus, and the items that highlighted colors represent the most frequent nodes. For instance, in our revision we can observe that the keywords, assistive technology and braille are dark green and visual impairment is blue green. This is associated with the size of each node on the map.

Most articles are published in the Journal of Blindness and Impairment, followed by the Journal of Science Education for Students with Visual Impairment and International Journal of Human-Computer Studies. these journals represent important spaces to socialize and offer updated contributions about the assistive technologies used by visual impairment students to learn a second language. This is shown in Figure 4.

Moreover, the results allow us to recognize the most cited authors during the period 2019-2023, in terms of total citations of their works in our dataset (<https://tinyurl.com/24ovwvtz>). However, when reducing this analysis to the 17 selected articles, the behavior among the authors is different. This is shown in Figure 5.



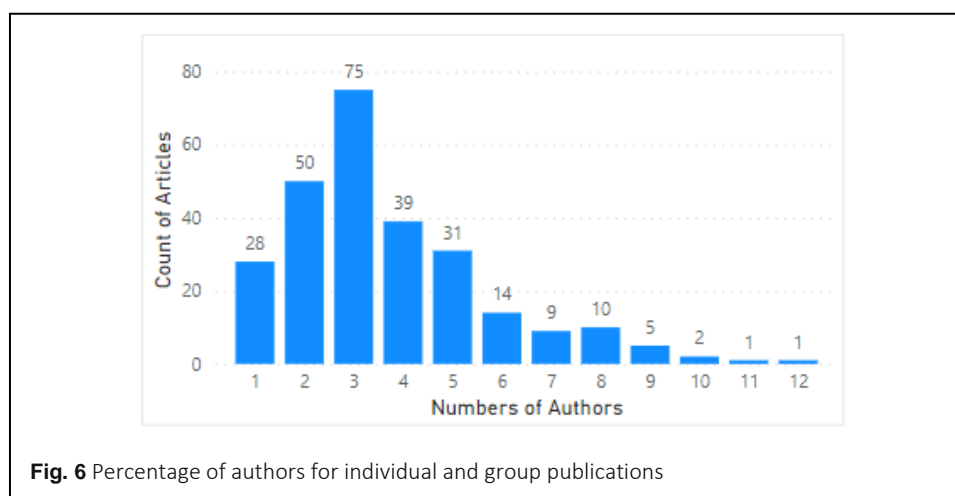
The data show the strong relationship between research and the legacy established in the literature, as showcased by researchers such as Argyropoulos et al. (see A8, A16), Kamali et al. (see A6 A) and Kapperman et al. (see A3, A14) in the last 5 years. This means that they have produced highly cited and high-impact work. Additionally, the research group composed by Kamali et al. has been working on visual impairment and assistive technologies with the same research group for two years consecutively, as opposed to Kapperman et al., whose works are carried out with different group of researchers. Similarly, Argyropoulos et al. have joined other research groups due to the covered topics; digital talking books and students' impairment choices and preferences. These new forms of integration among researchers make strong and cohesive interdisciplinary groups and the collaboration among them allows knowledge construction to become sustainable researchers (Freeth & Caniglia, 2020).

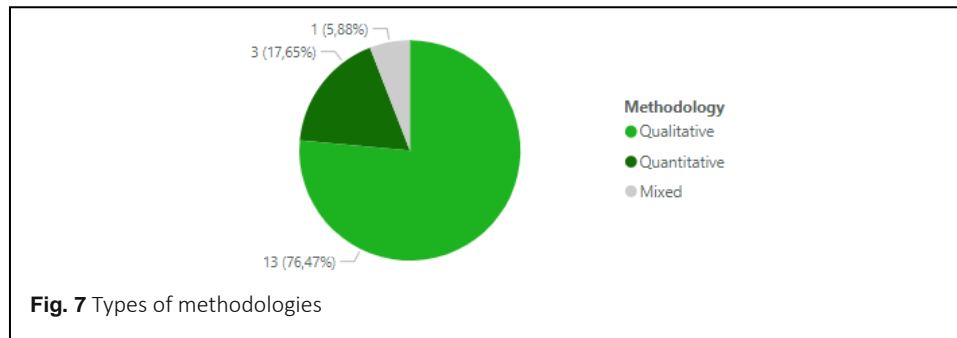
In addition, Figure 6 shows large nodes linked to others within the co-citation networks of individual authors and closest authors. Likewise, another behavior is observed whereby the authors seemingly prefer to work individually, while others work in groups or collectives. This figure shows that from 17 articles, eight were written by three authors; one was written by an individual researcher, four by two authors and four papers by more than three authors. From this, it can be interpreted that the written intellectual production about visual impairment has received attention recently.

From the in-depth analysis of the 17 articles selected from one database such as Scopus and the four virtual libraries of IEEE, Sage, Eric and Science Direct, listed in Appendix, the main results are described in relation to the research questions that were the focus of this SR.

### Methodological designs employed in language learning apps for VIU

In this SR, the frequency of methodologies employed is shown in Figure 7.





Seventeen studies were coded into different types of research methods. The vast majority of articles reviewed (76.47%) were qualitative studies; whilst 17.65% was quantitative in nature. Additionally, the 5.88 % was mixed methods. Most of the cases are under the umbrella of a qualitative approach, and the databases categorized practice reports as research articles that were relevant to the SR parameters.

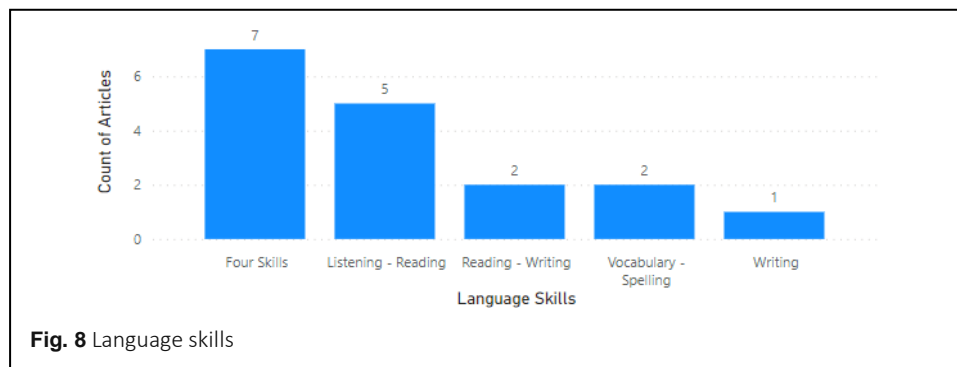
#### Language skills addressed in language learning apps for VIU

Among the 17 studies analyzed, it was found that 7 articles addressed four skills (writing, reading, speaking, and listening); 1 article focused solely on writing ability and 9 articles focused on two skills or subskills: Spelling and vocabulary (2), Reading and writing (2), Speaking and listening (1), and Listening and reading (1).

There is a propensity to work on skills in an integrated fashion, combining either 4, 3, or 2 skills. A similar characteristic is observed while working on subskills, where, for example, spelling is combined with vocabulary. Figure 8 shows the different language skills addressed in the 17 studies.

#### Affordances and limitations encountered while designing and implementing language learning apps for VIU

For this particular SR, the affordances and limitations encountered are listed in Table 3.

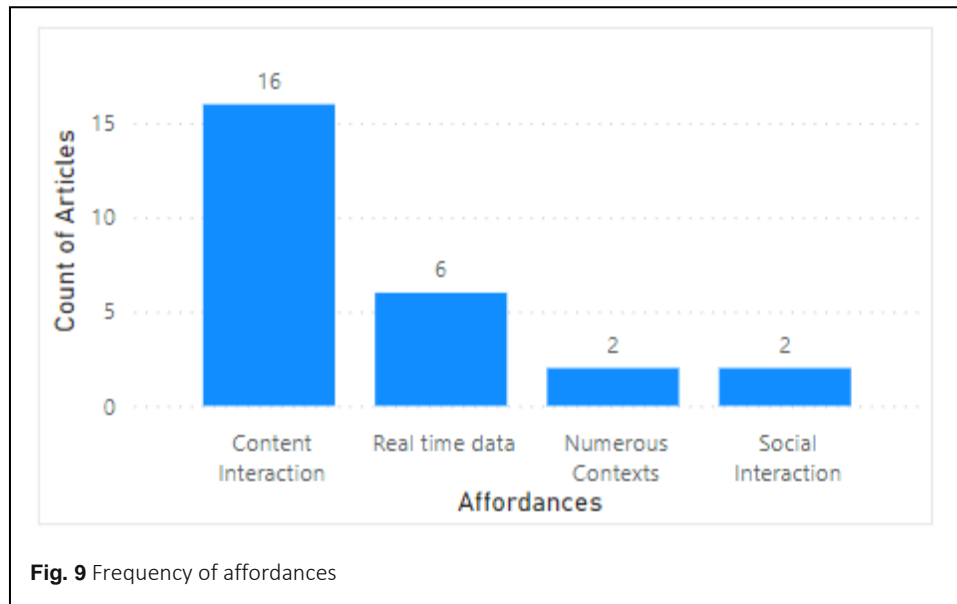


**Table 3** Affordances and limitations in MALL

Article	Skills	Affordances		Limitations	
A1	Writing	Content interaction: audio information Numerous contexts: portable	Video modeling leads to independent success in utilizing an iPad	Pedagogical	Focus on one single skill and first language
A7	Speaking and listening	Content interaction: audio information Social interaction: instantaneous	WhatsApp voice notes	Psychological	Subjective reflections on progress
A8	4-Skills	Real-time data Content interaction: audio information	Digital talking scripts through synthetic speech and DAISY	Pedagogical	Parameters of the impact that aural technology are still missing
A10	4-Skills	Content interaction: audio information	Converting content depicted by comic books into an auditory format	Technical	Privacy issues regarding the data collected as well as copyright issues regarding the content
A9	Vocabulary, spelling	Content interaction: audio information Real-time data	Audio feedback is crucial for VIS Data and content should be presented in a sequenced and structured manner	Pedagogical	Problems in understanding the explanations provided and keyboard usage competency
A12	4-Skills	Content interaction: audio information	Verbalization of the test demands more time	Technical	Practical operational features into test design: feedback protocol and trial screen readers and braille tests should be pursued
A11	4-Skills	Content interaction: Braille reading and screen reader	Using JAWS and MELDICT, the visually impaired student's English-learning endeavors were both pleasant and fruitful Boosting vocabulary understanding	Technical	Time consuming
A15	Reading and writing	Content interaction: interactive tools Audio information	Auditory feedback Automatic read-aloud support	Pedagogical	Creating the texts and activities as well as the instructions might be challenging
A16	Listening and reading	Content interaction: Braille reading Audio information	Traditional braille reading and printed materials Aural reading	Pedagogical	Lack of special education teachers' knowledge and experience in using relevant AT devices Students' slower performance

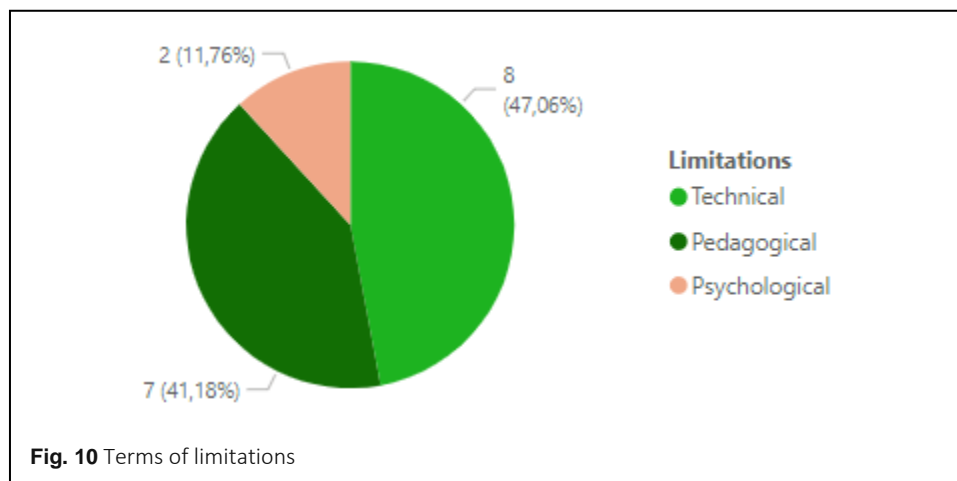
Article	Skills	Affordances		Limitations	
A14	4-Skills	Real time data Content interaction: Screen reader	Immediate access to the material Efficient time management	Technical	Software voice might be unintelligible Software configuration and downloading needs attention
A4	Listening, spelling (subskill), reading, writing	Real time data Numerous contexts: portable Content interaction: touch screen, auditory output, gestural input, vibration feedback	Available in Bangla Android based	Technical	Non affordable for developing countries
A17	4-Skills	Real time data	Adjustments provided with time extension	Psychological	Frustration caused by the impracticality of assistive technologies, group conflict and lack of support
A5	Reading and listening	Content interaction Social interactions: instantaneous	Reading speed improvements	Technical	Time consuming Few students' participations delay Lack of technological students' skills
A3	Reading and speaking	Content interaction: the screen readers Job Access with Speech (JAWS) and NonVisual Desktop Access (NVDA)	JAWS and NVDA support Russian pronunciation. The JAWS screen reader was efficiently for integrating the voice, text, and braille display	Technical	Problems with navigation. Some keys for the Russian language interfered
A2	4-Skills	Real time data Content: easy to access (adapted)	Immediate availability Efficient time	Pedagogical	Lack of trained teachers that use effective pedagogical strategies
A13	4-skills	Content interaction: magnifiers, audio materials, screen readers and laptops with screen readers	A variety of assistive technologies Extra time to complete tasks	Technical	Braille system does not support pictures, charts, and tables
A6	4-skills	Real time data Content interaction: practical, individualized and meaningful instruction Audio information	Time efficiency instantaneous access to content	Technical	Internet dependency





As observed in the figures, content interaction focused on audio information and real-time data or information availability to mobile learners are two of the most important affordances identified. Additionally, other content interaction categories such as writing, images, note taking and readings are also part of the concerns that this field has regarding VIU. The other two categories were instantaneous social interaction and numerous contexts, in which the ubiquity and portability of the devices were relevant for the study.

In terms of limitations, the technical (47.06%) ones are the most presented and common issues while combining MALL and visual impairment: Braille contractions, screen readers default settings, connectivity, time efficiency, accessibility of materials, privacy, and copyright concerns. The second type of limitation found were the pedagogical issues (41.18%), which depicted difficulties regarding teacher training, assessment, classroom



time management, instructional design, and learning outcomes. The third type of limitation found was the psychological issue, in which design and content were outlined as features that should be presented in a sequenced and structured manner to avoid confusion and frustration.

It is important to outline that the process of reviewing the manuscript revealed numerous vision problems. However, their classification is dependent on a number of factors, including congenital, accidental, aging, or disease-related (Douglas & McLinden, 2004). Each sort of visual impairment signifies a distinction of each individual in terms of learning at various socioemotional levels. As a result, learning is more relevant when students pay attention to their surroundings and comprehend not just the emotions but also the types of impairment suggested (Lang et al., 2017; Roe, 2008).

## **Discussion**

In this section, we address our three questions; the methodologies employed in MALL apps aimed at language learning for students with visual impairment; the language skills addressed in those apps, and the affordances and limitations encountered while designing and implementing MALL Apps.

For research question 1, many authors employed qualitative methods due to the valuable insights that can be provided in different social patterns by keeping authentic educational scenarios (Bal & Trainor, 2016; Kurth et al., 2015; Leko et al., 2015). Besides, the instruments used to collect data have “a conversation” with participants in focus groups or interviews where voices are heard and embedded in the research team (Jayawickreme et al., 2012; Lester & Nusbaum, 2018), and offer the opportunity to access enough depth of information that might contribute to transform pedagogical practices (Kozleski, 2017).

The vast majority of articles reviewed were case studies due to the nature of the target population. The number of VIU found in classrooms and educational scenarios tends to be small and with different degrees of impairment, which implies a necessity to analyze each situation separately, given the complex circumstances and ambiguous resolutions. If there are insufficient prior published works and the researcher’s objective relates to “who,” “what,” “where,” “how,” and “why” issues, experts with a long history in scientific education such as Yin (2018) and Mills et al. (2009) advise using case studies for analyzing student learning results.

Among the limitations encountered in the methodologies applied by different authors, it is clear that practice reports have been disregarded since conventional scientific-empirical methodologies have controlled the majority of disciplines (Canagarajah, 1996). We had the concern that their length and structure were not suitable for the research, or that they were viewed as poor-quality materials. However, databases categorized these as relevant documents for SR. It is also important to state that some works have been supported by

mixed methods methodologies which aim to transcend qualitative approaches and explore a manner to reduce the risk of bias or confusing outcomes.

Additionally, for research question 2, we examined the skills studied by the different mobile learning-oriented studies. The majority of works are focused on the integration of the 4 skills, since language learning frameworks along with international standards aim to develop them simultaneously in order to respond to academic and working necessities, as they have been pursued for future language assessment advance and research reflections to improve testing experience for all users (Guzman-Orth et al., 2016). It is worth pointing out that although the target population of this review has got visual impairments, there is a clear intention of moving towards policies of inclusion and integration at different levels: full courses, international certifications, tests preparations, training, or simply lifelong learning.

Reading and writing (including spelling) are generally viewed as the most demanding skills to learn for VIU since their nature relies on visual aids. Nonetheless, they are the second most popular skills explored due to three major assistive technologies that support students: Braille displays, haptic technologies, and screen readers. For this particular study, the use of Braille and its correspondent transition to m-Braille adheres to an adaptation to mobile learning and the incorporation of Braille in the digital format given that texting key to mobile communication and connectivity, but at the same time needs to become an eyes-free tool (Lu et al., 2017; Romero et al., 2011).

In the case of screen readers such as JAWS (Job Access with Speech) and MELDICT (Mitra Netra Electronic Dictionary), listening emerges as an incidental skill that is mainly connected to a motivating and trusted sense for VIU: hearing. As we can observed, listening plays an important role in MALL. In fact, this review outlines a Braille interface for listening lessons, speaking, and listening WhatsApp notes to integrate both skills in daily routines and speaking and listening – the DAISY program – to enhance participation and autonomy.

Several activities developed for authors are integrated to listening either to maintain inclusion and attention of people involved or to respond to cognitive and technical processes (Marpaung et al., 2022). This finding suggests that aural input is frequently used to compensate for a lack of visual input. For instance, reading duties are conducted using screen-reading software, which reads the text aloud. VIU frequently use the word “read” when they actually listen to texts because information in the digital format is easier to obtain than written texts. Although receiving information through reading and listening are two different processes, it is believed that receiving information through hearing, like reading Braille, is sequential by nature. In conclusion, it is a form of reading while listening (Veisapak et al., 2012).

From these four skills, authors also revealed an interest in spelling, as a manner to raise awareness towards clarity on written texts and semantic knowledge of vocabulary to complement wider skills in which grammar-based and traditional activities are replaced by tasks and other communicative approaches. Some authors have already started testing the effects of integrating tasks and mobile learning and the potential benefits and challenges of integrating tasks into technology-mediated language learning, with a specific focus on MALL. Mobile technologies can be employed as they offer digitally-facilitated site-specific learning and support a wide range of learning activities as well as adaptation to cognitive and sensorial disabilities (Chen & Lin, 2018; Fang et al., 2020; Xue, 2022).

Regarding research question 3, content interaction focused on audio information and real-time data or information availability for mobile learners are two of the most important affordances found in this review. Additionally, other content interaction categories such as writing, images, note taking and readings are also part of the concerns that this field has over VIU. Unfortunately, a significant proportion of developers are unaware of accessibility design principles (Alshayban et al., 2020). Therefore, content access has emerged as the major concern in this review.

Two other categories were instantaneous social interaction and numerous contexts, in which the ubiquity and portability of the devices along with peer and instructors' interaction were relevant for the study. Some software items and affordances are difficult to process in mobile devices and are mostly supported by computers, but more recent studies have shown how this process is moving towards universality and social presence simultaneously (Ally & Prieto-Blázquez, 2014). In terms of limitations, most of them were technical (8 out of 17) in which A10, A12, A11, A14, A4, A5, A3, A13 and A6 presented common issues while combining MALL and visual impairment: Braille contractions, screen readers default settings, connectivity issues, time efficiency, accessibility of materials, privacy, and copyright concerns. The second type of limitation identified was pedagogical since 7 out of 17 papers reviewed: A1, A8, A9, A15, A16 and A2 exposed difficulties regarding assessment, teacher training, classroom time management, and learning outcomes. A third type of limitation was psychological (2 out of 17) which corresponded to articles A7 and A17 from the metrics, determined that people who are visually impaired, blind or have low vision need varied support, from policies and programs to access to architecture, technologies and support from professionals and family, especially in educational contexts. The educational experiences that were investigated place technology as an important didactic resource for learning, but as innovative solutions need to be adapted to the realities of these people, particularly if we recognize the existence of different degrees and levels of visual impairment, either by disease or because it is the result of an accident or congenital form. In fact, current works related to innovations in education of visual impairment have outlined the use of typhlo-technical tools, natural

inclusion and autonomous participation by focusing on teacher and student training, a concern regarding accessibility and usability features, and finally a personalized adaptation of feedback processes (Cárdenas & Inga, 2021; Fuentes et al., 2022; Maćkowski et al., 2023).

This implies that pedagogically, their learning difficulties and different special educational needs have to be addressed. For this reason, we recognize the value of assistive technology and mobile applications for language learning but accept that their use will depend on who are the people with these disabilities so that education is equal for all without discrimination or exclusion (Delors, 1996; UNESCO, 2012, 2015a, 2015b). To this end, according to Zamora and Marin (2021), it is necessary to “provide a model of education based on inclusion and equity that favors equal opportunities and learning for any group of people” (p. 109).

Kamali-Arslantas et al. (2021) claimed that current categorizations of affordances have been evolving into three main concerns: accessing content in which practicality and time efficiency are relevant, individualized instruction or providing the opportunity to students to learn based at their own pace and based on different vision levels, in addition to tracking progress through auditory feedback to increase self-encouragement and motivation. These current trends align with the categories used for this study since content interaction focused on audio information and real-time data or information availability is equivalent to accessing content and clarifies the effort MALL is making to overcome limitations on this matter. Another category is instantaneous social interaction that responds to the valuable tracking progress that might be obtained from peers and teachers, and the importance of incorporating this data for future designs.

Regarding Braille and mobile learning, the use of contractions, the transition to reading and the time-consuming activities while using it in the classroom exposed the constraints entailed in this system. Nonetheless, its value remains intact in terms of inclusion and multimodality and implies at the same time one of the paramount psychological aspects of MALL in aiding learners with visual impairment: defeating stigmatization by guaranteeing accessibility to everyone and respecting their rights to education.

## **Conclusion**

In this review, a critical appraisal of the research papers has allowed us to shed light on the path towards assistive technology, usability guidelines and the importance of device quality in the field of language learning apps for the visually impaired. ICT certainly plays a significant role in the success of certain language skills development such as reading and writing due to the clarity of inclusion policies applied notwithstanding the required investment of time and costs.

Our research concludes that the majority of papers aimed to integrate the four language skills. Such an approach aligns with one of the MALL objectives: retaining the integration of language abilities as suggested by contemporary language learning theories, which avoid the teaching of individual words and structures by focusing on the incorporation of communicative approaches.

Given its rapid development and continuous progress within the context of new pedagogies for multiple learners with special needs, MALL is anticipated to be among the most effective advances in language instruction. In addition, it has the potential to allow greater inclusivity if innovations are taken into consideration while selecting the assistive features, affordances, and limitations for language learning, along with appropriate research methods to expand our understanding of this specific sector of vulnerable individuals.

Regarding assistive features, VIU are assisted by mobile touchscreen technology in which Braille-based approaches, voice assistants and screen readers are also available. By considering the affordances and limitations of the set of apps, educators can help to create technologically enhanced learning environments that optimize the advantages, establish meaningful connections between technologies and students, and mitigate the disadvantages associated with the ubiquitous presence of mobile devices (Bernacki et al., 2020; Crompton, 2017; Wright & Parchoma, 2011). Additionally, these revisions can propose recommendations for the guarantee of multimodality, enhancing the utilization of mobile devices in educational contexts which aim to integrate mobile and psychological learning theories, as a manner to explore numerous innovative and captivating research domains related to the inclusion of VIU.

A final consideration of this study is that technical limitations represent a major concern in terms of research, followed by pedagogical and psychological limitations. This shows the importance of developing technical adaptations and searching for universal design improvement, particularly in mobile learning frameworks that could continuously empower users.

Further research is needed to investigate the three essential dimensions related to the design of an accessible language learning app. From the technological and pedagogical dimensions, there is a need to determine how affordances and accessibility features can offer appropriate assessment and meaningful feedback to VIU, since little has been done regarding this. The methods found in this review were mainly case studies, yet it would be valuable to apply others that aim to contribute to language learning and visual impairment theories. Finally, from the perspective of the psychological dimension, we aim to continue exploring mobile learning and communicative approaches with accessible design as a way to provide greater inclusion, affective scaffolding and the socioemotional elements necessary for both sighted and VIU beyond technology.

**Appendix: List of articles selected for SR**

Article code	Publication year	Author	Title	Publication title	Quartiles
A1	2020	Chang, C.-J., Lo, C. O., & Chuang, S.-C.	Applying Video Modeling to Promote the Handwriting Accuracy of Students with Low Vision Using Mobile Technology	Journal of Visual Impairment & Blindness	Q3
A2	2022	Price, K. E.	Todo 'Stá Bien Chévere, Don't You Worry 'Bout a Thing: Promising Practices in Literacy Instruction for English Language Learners Who Are Blind or Have Low Vision	Journal of Visual Impairment & Blindness	Q3
A3	2021	Kapperman, G., Kelly, S. M., & LeRette-Kauffman, H.	The Study of Russian as a Foreign Language for English-Speaking Braille Readers Using the Job Access with Speech or NonVisual Desktop Access Screen Reader and a Refreshable Braille Display	Journal of Visual Impairment & Blindness	Q3
A4	2021	Nahar, L., Sulaiman, R., & Jaafar, A.	"Bangla Braille Learning Application" in Smartphones for Visually Impaired Students in Bangladesh	Interactive Learning Environments	Q1
A5	2020	Kamei-Hannan, C., McCarthy, T., D'Andrea, F. M., & Holbrook, M. C.	Investigating the Efficacy of Reading Adventure Time! For Improving Reading Skills in Children with Visual Impairments	Journal of Visual Impairment & Blindness	Q3
A6	2021	Kamali Arslantas, T., Yildirim, S., & Altunay, B.	Educational Affordances of a Specific Web-Based Assistive Technology for Students with Visual Impairment	Interactive Learning Environments	Q1
A7	2022	Karthika, J., & Selvam, V.	Accessible and Engaging Voices: Teaching English to Adult Second-Language Learners with Visual Impairment Using WhatsApp Voice Notes in India	British Journal of Visual Impairment	Q3
A8	2019	Argyropoulos, V., Paveli, A., & Nikolarazi, M.	The Role of DAISY Digital Talking Books in the Education of Individuals with Blindness: A Pilot Study	Education and Information Technologies	Q1

Article code	Publication year	Author	Title	Publication title	Quartiles
A9	2022	Kamali-Arslantas, T., Yildirim, S., & Altunay, B.	Designing and Developing an Accessible Web-Based Assistive Technology for Students with Visual Impairment	Assistive Technology	Q3
A10	2021	Samarawickrama, C., Lenadora, D., Ranathunge, R., De Silva, Y., Perera, I., & Welivita, K.	Comic-Based Learning for Students with Visual Impairments	International Journal of Disability, Development, and Education	Q2
A11	2022	Hamid, S. M., Setiawan, S., & Anam, S.	Portraits of Assistive Technology in English Learning for Visual Impaired Students in Higher Education	Journal of Higher Education Theory & Practice	Q4
A12	2019	Fairbairn, J., & Spiby, R.	Towards a Framework of Inclusion: Developing Accessibility in Tests at the British Council	European Journal of Special Needs Education	Q1
A13	2022	Al Siyabi, J., Tuzlukova, V., Al Kaabi, K., & Hadra, M.	Assistive Technology in the English Language Classroom: Reality and Perspectives	Journal of Language Teaching and Research	Q2
A14	2021	Kapperman, G., Ortner, A., & Midgley, S.	Configuring the BrailleNote Touch+ for Students with Visual Impairments in a Foreign Language Class	Journal of Visual Impairment & Blindness	Q3
A15	2020	Jerome, M., & Ainsworth, M.	Literacy Acquisition for Students with Severe Disabilities Making It Happen through Assistive Technology	Teaching Exceptional Children	Q3
A16	2019	Argyropoulos, V., Padeliadu, S., Avramidis, E., Tsiakali, T., & Nikolarazi, M.	An Investigation of Preferences and Choices of Students with Vision Impairments on Literacy Medium for Studying	British Journal of Visual Impairment	Q3
A17	2020	Attachoo, B., & Sitthitikul, P.	The Lived Experiences in English Language Learning of the Thai Visually Impaired Students in the Inclusive Classroom	English Language Teaching	N/A



**Abbreviations**

ADA: The Americans with Disabilities Act; ICT: Information and Communication Technologies; JAWS: Job Access with Speech; MALL: Mobile Assisted Language Learning; MELDICT: Mitra Netra Electronic Dictionary; SR: Systematic reviews; VIU: Visually Impaired Users.

**Authors' contributions**

HR, AP and KV designed the study, abstract and research questions and contributed to the data collection and wrote the original manuscript with support and guidance from all the other authors. MD and EV provided feedback to analyze the data, tables and graphs organization as well as contributed to the review and revision of the final manuscript. MJ and CK supervised the work regarding the software implemented as well as contributed to the planning, discussion of the results and the final manuscript. All authors read and approved the manuscript.

HR: Introduction, Method, Results, Discussion

AP: Method, Results, Conclusion, Figures

KV: Abstract, Introduction, Research questions, Tables

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### Declarations

#### Competing interests

The authors declare that they have no competing interests.

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