



Perceptions and Participation of Visually Impaired Students in an AI-Based Audio Braille Dictionary for English Learning

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ABSTRACT

Purpose: This study was motivated by the limitations of English learning for visually impaired students, which is still dominated by conventional Braille without audio support, leading to suboptimal understanding of pronunciation, vocabulary, and language context. This study aims to describe students' perceptions, examine the role of an AI-based Braille–audio dictionary in supporting English learning, analyze students' participation, and identify learning obstacles and experiences. **Methods:** This qualitative study employed a phenomenological approach. Data were collected through participatory observation, in-depth interviews, and documentation involving 12 visually impaired students from SLB Negeri Mempawah and SLB Negeri Rasau Jaya. Data were analyzed using thematic analysis, involving data reduction, coding, categorization, and interpretation. **Findings:** The results show that the AI-based Braille–audio dictionary improved students' vocabulary acquisition, pronunciation accuracy, and contextual understanding of English. Students demonstrated higher engagement, greater learning independence, and more active participation during learning activities. However, the study also found limitations, including uneven audio processing speed, dependence on device availability, and initial difficulties in adapting to dual-mode (Braille–audio) learning. **Research Implications:** The integration of AI-assisted Braille–audio media can enhance accessibility and inclusivity in English learning for visually impaired students. The findings provide practical implications for teachers and policymakers in developing adaptive learning technologies that support autonomy and participation in inclusive classrooms. **Originality:** This study contributes a novel approach by integrating AI-based Braille and audio systems in English learning for visually impaired students, offering a multimodal learning experience that supports vocabulary development, pronunciation, and contextual comprehension beyond traditional Braille instruction.



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INTRODUCTION

Article 31 paragraphs (1) and (3) of the 1945 Constitution of the Republic of Indonesia affirm that every citizen has the right to education, and the state is obliged to provide a national education system that enhances the intellectual life of the nation. This constitutional guarantee applies universally, including to persons with disabilities, such as students with visual impairments. Further affirmation is found in Law Number 20 of 2003 concerning the National Education System, particularly Article 5 paragraph (1) regarding equal rights to quality education, and Article 32 which regulates educational services for students with special needs. This commitment is strengthened through Law Number 19 of 2011 concerning the Ratification of the Convention on the Rights of Persons with Disabilities and Law Number 8 of 2016 concerning Persons with Disabilities, which obligate the government to ensure quality education in both inclusive and special education settings for persons with disabilities.

Although the juridical foundation of inclusive education in Indonesia is strong, its implementation in practice still reveals significant gaps. Students with visual impairments continue to face limitations in accessible learning facilities, a lack of educators who understand their learning needs, curricula and evaluations that are not fully adaptive, as well as social barriers affecting academic participation. One important issue is the limited availability of Braille learning materials and other supporting learning devices (Snigdha et al., 2022). In fact, Braille plays a fundamental role as a

text-access medium for visually impaired students because it enables independent reading, develops spatial understanding of written texts, and strengthens mastery of spelling and grammar (Adiba et al., 2020; Anitha & Elangovan, 2020; Assyifa, 2019). In English language learning, this function becomes even more essential because Braille helps students establish connections between word forms, sounds, and meanings through non-visual means.

However, conventional Braille alone is not fully sufficient to address the demands of English language learning, which requires mastery of pronunciation, intonation, vocabulary, and contextual language use. Therefore, audio support becomes important so that students are not only able to “read” texts but also to “understand” and “use” them communicatively. Findings by Fatmawati et al. (2023) indicate that Braille-based media can improve conceptual understanding, while Furwasyih et al. (2022) emphasize that audio support helps bridge perceptual gaps experienced by visually impaired users. Research by Dzunurain & Wasisto (2022) also demonstrates that Braille use is not optimal without alternative media that address learning needs more holistically. Thus, enriching Braille with audio and tactile media is highly relevant, particularly in English language learning contexts that require simultaneous phonological, semantic, and contextual processing.

A multisensory approach involving touch and hearing is considered an appropriate strategy for visually impaired students in learning English (Rossiani et al., 2022; Wiyannah et al., 2020). In this context, a Braille dictionary enriched with audio has the potential to become an effective adaptive medium, as it allows students to feel vocabulary entries while simultaneously listening to pronunciation and usage examples. Various studies on assistive technology have also shown that integrating text, Braille, audio, and digital systems can strengthen access and comprehension for visually impaired students (Dahniar et al., 2022; Kapgate et al., 2023; Snigdha et al., 2022). Furthermore, tactile media designed in a structured manner have been proven to enhance motivation, learning experiences, and vocabulary retention through more active and enjoyable activities (Kholifah, 2018; Setiawan et al., 2023; V.A.R. Barao et al., 2022).

The need for such adaptive media is clearly evident at SLB Negeri Mempawah and SLB Negeri Rasau Jaya. Based on preliminary observations, both schools still rely on conventional Braille books in English learning without standardized audio support. In fact, foreign language learning highly depends on listening, pronunciation, and strong language imagination (Rossiani et al., 2022). This condition indicates that English learning for visually impaired students in regional areas is still not fully supported by adequate multisensory media, even though previous studies have demonstrated the potential of audio-based assistive devices in improving learning accessibility for visually impaired learners (Dahniar et al., 2022).

In this situation, a Braille dictionary equipped with AI-based audio offers a relevant innovative opportunity. AI technology enables the provision of more adaptive audio features, such as repeated pronunciation, adjustable tempo, and sound emphasis according to students’ learning needs. This aligns with findings that properly designed audio can improve learners’ focus, engagement, and affective responses (Mamat et al., 2021; Widodo et al., 2024). In addition, machine learning-based approaches also have the potential to improve the accuracy of text conversion, transliteration, and Braille information presentation in bilingual or English learning contexts (Jha & Parvathi, 2019; Joshi et al., 2023). Thus, the function of a dictionary is no longer limited to serving as a vocabulary reference, but evolves into a learning medium that helps students understand words, sentence examples, pronunciation, and meanings in a more contextualized manner (Chandrasekaran et al., 2019; Hemalatha et al., 2022; Kapgate et al., 2023; Mathew et al., 2022).

Nevertheless, studies specifically exploring the perceptions and participation of visually impaired students regarding the use of AI-based Braille-audio media remain limited. In fact, the success of assistive technology innovation depends not only on technical sophistication but also on its acceptability, comfort, and meaningfulness for users (Adiba et al., 2020; Dzunurain & Wasisto, 2022; Ghayyor et al., 2018; Junaidin & Irham, 2021). Previous research indicates that the success of adaptive media is greatly influenced by the suitability of the design to students’ actual needs and usage contexts (Anitha & Elangovan, 2020; Arora et al., 2018; Kapgate et al., 2023; Kulkarni et al., 2019; Patil et al., 2021; Ramiati et al., 2020). Therefore, studies grounded in students’ direct experiences are essential to ensure that media innovations genuinely address their learning needs.

Based on the explanation above, although various studies have highlighted the benefits of Braille media, audio support, and AI-based assistive technologies in improving accessibility and learning outcomes for visually impaired students, most of these studies have focused on technical effectiveness and learning outcomes in general terms. There is still limited research that specifically explores how visually impaired students themselves perceive, experience, and actively participate in the use of an AI-based Braille-audio dictionary in English language learning contexts. In particular, empirical evidence regarding students’ lived experiences, emotional engagement, and participation in using multimodal (Braille-audio) AI-based learning tools remains underexplored. This gap is important because the success of assistive learning technology is not only determined by its technical features, but also by user acceptance, usability, and meaningful learning experience in real classroom settings.

Therefore, the problem addressed in this study is: how do visually impaired students perceive, experience, and participate in the use of an AI-based Braille–audio dictionary in English language learning? Accordingly, this study aims to explore in depth students’ perceptions, participation, learning experiences, and challenges in using the AI-based Braille–audio dictionary in inclusive English learning contexts at SLB Negeri Mempawah and SLB Negeri Rasau Jaya. The findings are expected to provide a more user-centered understanding of assistive technology implementation and contribute to the development of more inclusive and adaptive English language learning media.

METHOD

The qualitative phenomenological method was used in this study and aligned with the aim of exploring the lived experiences of visually impaired students in using an AI-integrated Braille-audio dictionary in English learning, particularly in Analytical Exposition Text material. This approach is appropriate for capturing subjective meanings, perceptions, and emotional-cognitive experiences that cannot be adequately represented through quantitative measures (Junaidin & Irham, 2021). This study was further supported by previous research emphasizing that the effectiveness of adaptive learning media should be understood through users’ direct experiences within authentic learning contexts (Adiba et al., 2020; Dzunurain & Wasisto, 2022; Fatmawati et al., 2023; Widodo et al., 2024).

The study was conducted at SLB Negeri Mempawah and SLB Negeri Rasau Jaya, which were purposively selected as inclusive education settings in non-urban areas with limited access to multimodal learning media. The preliminary study was conducted on October 14–15, 2025, followed by the main fieldwork on February 11–19, 2026, from 09.00 to 10.30 WIB. This chronological sequence was designed to ensure systematic preparation prior to data collection and is presented in accordance with the actual research process (Adiba et al., 2020; Junaidin & Irham, 2021).

The participants consisted of seven visually impaired students (Grade X), six parents, two teachers, and two principals. The selection of participants was based on purposive sampling to obtain rich and relevant information regarding students’ learning experiences. Data were collected through participatory observation, in-depth and semi-structured interviews, and documentation. However, it is noted that only the seven students were the primary informants in the analysis of learning experience, while parents, teachers, and principals served as supporting informants for triangulation purposes (Furwasyih et al., 2022; Junaidin & Irham, 2021; Rossiani et al., 2022).

Data analysis was conducted using interpretative thematic analysis, including transcription, open coding, theme development, categorization, and interpretation. The analysis process followed the steps proposed by Creswell and Poth (2018) and Moleong (2020). The study was also theoretically grounded in perception theory to examine sensory meaning-making processes and participation theory to analyze students’ engagement in learning activities. To ensure data trustworthiness, this study applied credibility, transferability, dependability, and confirmability. Credibility was strengthened through triangulation of sources and methods involving students, parents, and teachers. This approach ensured comprehensive validation of students’ learning experiences in the use of AI-based Braille-audio media.

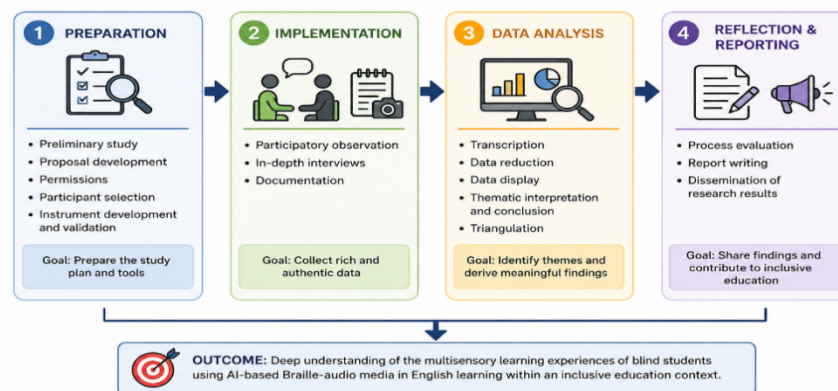


Figure 1. Research Procedure

The research procedure consisted of four stages: preparation, implementation, data analysis, and reporting. The preparation stage included preliminary study, licensing, participant selection, and instrument development. The implementation stage involved observation, interviews, and documentation. The analysis stage included transcription, data reduction, data display, and conclusion drawing. The final stage involved evaluation and reporting of findings.

RESULTS

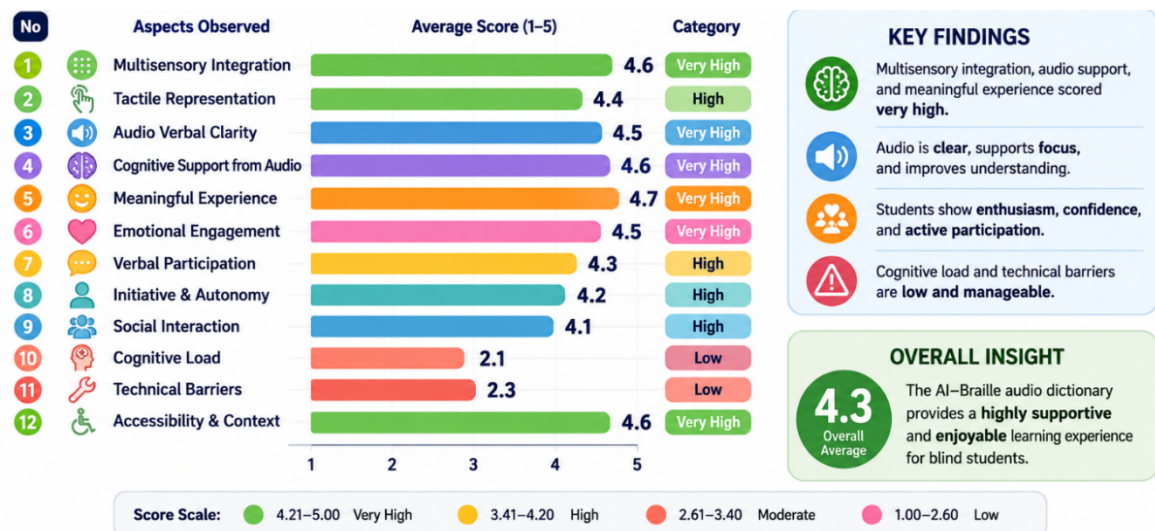
The preliminary study results showed that English learning at SLB Negeri Mempawah and SLB Negeri Rasau Jaya was still dominated by the use of conventional Braille without audio support, resulting in suboptimal understanding of pronunciation, vocabulary, and language context. In terms of institutional readiness, the schools demonstrated support for adaptive learning media innovation, although they were constrained by limited facilities and resources. The participant selection process identified relevant subjects, namely visually impaired students who actively used Braille, along with teachers and principals as supporting informants, thereby enabling a comprehensive exploration of learning experiences.

Table 1. Research Instrument Grid

Nu.	Aspect	Core Concept	Implication
1	Multisensory	Touch, hearing	AI audio accompanies Braille
2	Tactile	Texture, mental imagery	Audio explains objects
3	Audio Verbal	Pronunciation & meaning	AI audio: words & examples
4	Cognitive	Supports focus & abstraction	Adaptive pacing & repetition
5	Emotional	Learning closeness	Natural & interactive audio
6	Cognitive Load	Simplifies processes	Concise & structured audio
7	Accessibility	Suitable to student context	Simple & relevant design

The development of the research instruments resulted in interview guidelines and observation sheets that were validated by experts, focusing on students' perceptions, understanding, and participation toward Braille-audio media. Participatory observation was conducted directly during English learning activities at SLB Negeri Mempawah and SLB Negeri Rasau Jaya, West Kalimantan, with the researcher acting as the key instrument who was empathetically involved in classroom activities.

The observations were carried out naturally to capture the authentic behavior of visually impaired students in using the AI-based audio-enhanced Braille dictionary, including multisensory interactions (touch–hearing), cognitive responses, emotional engagement, and forms of active participation. Each indicator was assessed using a scale of 1–5 and supported by field notes containing concrete student behaviors as empirical evidence. This process was also intended to support triangulation with interview and documentation data to strengthen the credibility of the research findings.



Picture 2. Summary of Observed Aspects

The observation results indicated that the AI-enhanced audio Braille dictionary was able to provide integrated multisensory learning, in which students combined tactile and auditory experiences to understand vocabulary more comprehensively. Audio support was proven to strengthen focus, facilitate comprehension of meaning, and clarify pronunciation and intonation, thereby functioning as a primary facilitator in the language learning process. From the affective perspective, students demonstrated high engagement characterized by enthusiasm, comfort, and increased

self-confidence, which contributed to greater verbal participation and social interaction. In addition, some students began to demonstrate independence in using the learning media. Although minor obstacles such as audio speed and technical issues were identified, these were not significant. Overall, the media proved to be effective, accessible, and relevant in supporting inclusive English learning for visually impaired students.

In-depth interviews were conducted individually with 10 visually impaired students (7 totally blind students and 3 low-vision students) using a multisensory approach, where students were allowed to touch and use the AI-based Braille-audio dictionary while answering questions. Questions were delivered simply and one at a time, with reflective pauses to capture the students' authentic experiences. The process concluded with meaning confirmation (member checking) to ensure the accuracy of the researcher's interpretation of the students' subjective experiences.

Table 2. Findings from Interviews with Seven Students

Nu	Aspect	Main Findings	Category	Description
1	Perceived Ease	Totally blind students benefited from audio; low-vision students benefited from audio–touch–residual vision	Very Positive	Easy navigation
2	Comfort	Totally blind students felt secure; low-vision students felt more flexible	Very Positive	Physical and psychological comfort
3	Audio Clarity	Audio supported pronunciation and comprehension	Very Positive	Intonation supported learning
4	Multisensory	Audio–Braille integration enhanced understanding	Very Positive	More effective than a single mode
5	Meaningful Experience	Faster vocabulary comprehension; emergence of learning insight	Very Positive	Improved understanding
6	Emotional & Motivation	Increased confidence and learning enthusiasm	Very Positive	Audio provided emotional support
7	Verbal Participation	More active in asking and answering questions	Positive	Influenced by audio clarity
8	Learning Autonomy	Began learning independently to find word meanings	Positive	Initial adaptation still needed
9	Social Interaction	Increased discussion with teachers and peers	Positive	Media supported communication
10	Learning Focus	Improved focus, although sometimes distracted by fast audio	Positive	Influenced by audio pacing
11	Technical Barriers	Minor issues with audio, devices, or electricity	Low	Not dominant
12	Dictionary Navigation	Some students were still slow in finding words	Moderate	Requires habituation
13	Cognitive Load	Audio was too fast/long for some students	Low–Moderate	Requires pacing adjustment
14	Pedagogical Barriers	Requires training and teacher assistance	Moderate	Teachers remain important
15	Recommendations	More flexible audio and additional examples	Constructive	Suggestions for media improvement

Furthermore, the development of learning autonomy and more active social interaction with teachers and peers also became evident. Nevertheless, minor barriers remained, including excessively fast audio tempo, technical device issues, and the need for adaptation in dictionary navigation and teacher assistance during the initial stage. Overall, students perceived the AI-based Braille-audio media as an effective, user-friendly, and relevant learning tool to support inclusive English education. Interviews with parents were conducted in a semi-structured and reflective manner involving six parents of visually impaired students as supporting informants for data triangulation. The interviews were carried out individually using an empathetic approach to explore parents' experiences in assisting their children in using the Braille dictionary integrated with Artificial Intelligence (AI)-based audio in English learning. The questions focused on changes in students' learning behavior, levels of independence, learning motivation, emotional engagement, barriers to media use, and the relevance of the media to the learning needs of visually impaired students.

The interviews employed simple and contextual language so that parents could deeply express their experiences based on the children's daily conditions at home and observations after the implementation of the learning media. Each important piece of information was reconfirmed through member checking to ensure the accuracy of the researcher's interpretation. This process was also used as a source triangulation strategy to strengthen the validity of findings obtained from classroom observations, documentation, and interviews with students and teachers.

Table 3. Findings from Parent Interviews

Nu	Aspect (Research Indicators)	Findings from Parent Interviews	Category	Implication
1	Multisensory	Children began combining Braille and audio independently	Very Positive	Strengthens multisensory learning
2	Tactile	The combination of touch and audio facilitates comprehension	Positive	Braille remains the primary foundation
3	Audio Verbal	Pronunciation improved and self-confidence increased	Very Positive	Strengthens language skills
4	Cognitive Support	Focus and vocabulary comprehension improved	Very Positive	Strengthens cognitive processes
5	Emotional Engagement	Children became more comfortable, happy, and enthusiastic	Very Positive	Learning motivation increased
6	Cognitive Load	Some students required repeated audio playback	Low–Moderate	Audio tempo needs to be adaptive
7	Accessibility	The media matched the needs of visually impaired students	Very Positive	Contextually relevant
8	Learning Autonomy	Children began studying independently at home	Positive	Independence developed
9	Social Interaction	Family discussions related to learning increased	Positive	Learning communication strengthened
10	Technical Barriers	Minor issues with devices and initial use	Low	Technical support required
11	Family Support	Parents found it easier to assist learning	Very Positive	Home–school collaboration strengthened
12	Recommendations	More flexible audio and expanded materials were suggested	Constructive	Media development is needed

Although minor obstacles were still identified, such as the need for repeated audio playback, technical device issues, and the necessity for more adaptive audio pacing, parents considered this media relevant to the needs of visually impaired students and helpful in supporting learning assistance at home. Overall, parents viewed the AI-based Braille–audio dictionary as an effective, accessible learning medium that supports stronger collaboration between schools and families in inclusive education. Semi-structured interviews were conducted with English teachers at SLB Negeri Mempawah and SLB Negeri Rasau Jaya as triangulation key informants. The interviews focused on teachers' experiences in observing student responses, the effectiveness of multisensory media, changes in participation, and technical and pedagogical barriers. Each response was explored contextually based on classroom learning practices and reflectively confirmed to maintain data validity.

Table 4. Findings from Teacher Interviews

Nu	Aspect	Main Findings (SLB Mempawah vs SLB Rasau Jaya)	Description
1	Initial Student Response	Mempawah students were enthusiastic from the beginning; Rasau Jaya students adapted after assistance	Positive responses in both schools
2	Tactile Representation	Braille helped basic vocabulary comprehension	Tactile function is important
3	Role of Audio	Audio assisted pronunciation and meaning comprehension	Main learning component
4	Tempo & Repetition	Suitable in Mempawah; adjustments needed in Rasau Jaya	Student needs vary
5	Emotional Engagement	Students became more comfortable and confident	Strong affective impact

Nu	Aspect	Main Findings (SLB Mempawah vs SLB Rasau Jaya)	Description
6	Moment of Understanding	Teachers observed moments of “instant understanding”	Increased learning insight
7	Contextual Understanding	Example sentences helped language usage	Learning became more applicable
8	Student Participation	Increased activeness in asking and answering questions	Participation improved
9	Learning Autonomy	Students became more independent	Gradual independence
10	Social Interaction	Increased teacher–student and peer interaction	Media supports communication
11	Media Accessibility	Media availability remained limited	Facility support needed
12	Technical Barriers	Minor audio, device, or electricity disruptions	Barriers were not dominant
13	Cognitive Load	Audio was too fast for some students	Tempo control needed
14	Pedagogical Strategies	Teachers still guided media use	Teacher role remains important
15	Curriculum Suitability	Media suited SLB learning needs	Supports inclusive learning
16	Recommendations	More flexible audio and expanded content	Direction for media development

From affective and participatory perspectives, teachers observed increased learning comfort, self-confidence, verbal involvement, and social interaction during classroom activities. In addition, gradual development of students’ learning independence became evident in their ability to use the media autonomously. However, minor obstacles remained, including limited facilities, technical device issues, and the need for more adaptive audio pacing according to students’ characteristics. Teachers also emphasized that pedagogical guidance remained necessary to optimize media use. Overall, the AI-based Braille–audio media was considered relevant to the learning needs of special schools, supportive of inclusive education, and worthy of further development through enhanced audio features and expanded learning content.

Semi-structured and reflective interviews were also conducted with principals at SLB Negeri Mempawah and SLB Negeri Rasau Jaya as key informants at the policy and institutional levels. The interviews focused on student acceptance, learning impact, participation, institutional barriers, and policy support for the use of the AI-based Braille–audio dictionary. Each response was analyzed contextually and used as triangulation data to strengthen findings from students and teachers.

Table 5. Findings from Interviews with Two School Principals

Nu	Aspect	Main Findings (SLB Mempawah vs SLB Rasau Jaya)	Description
1	Student Acceptance	Mempawah highly positive; Rasau Jaya positive with initial adaptation	Media well accepted
2	Role of Audio	Audio assisted pronunciation and meaning comprehension	Main learning component
3	Tactile Suitability	Braille suited student needs	Supports learning access
4	Motivation & Attitude	Motivation and self-confidence increased	Strong affective impact
5	Cognitive Support	Helped students understand abstract material	Facilitated learning
6	Meaningful Learning	Aligned with inclusive education	Learning became more meaningful
7	Student Participation	Increased activeness in both schools	Indicator of learning success
8	Learning Independence	Students began independently learning vocabulary	Positive development

Nu	Aspect	Main Findings (SLB Mempawah vs SLB Rasau Jaya)	Description
9	Social Interaction	Interactions became more active and collaborative	Classroom dynamics improved
10	Accessibility	Media availability remained limited	Facility support needed
11	Infrastructure	Device, electricity, and technical constraints	Institutional barriers
12	Cognitive Load	Audio tempo and structure required adjustment	Development feedback
13	Teacher Readiness	Teachers were adequately prepared but needed further training	Capacity strengthening
14	School Policy	Schools supported inclusive innovation	Institutional commitment
15	Media Effectiveness	Media effectively improved English learning	Worthy of development
16	Recommendations	Audio enhancement and broader implementation	Strategic development direction

From an institutional perspective, principals observed the development of students' learning independence and increased meaningfulness of learning that supported the goals of inclusive education. Nevertheless, institutional barriers remained, including limited facilities, device infrastructure, technical support, and the need to adjust audio tempo to better suit the characteristics of visually impaired students. Principals also noted that teachers had demonstrated sufficient readiness in implementing the media, although further competency strengthening through additional training was still necessary. Overall, the AI-based Braille–audio media was considered worthy of broader development through improved audio features, enhanced supporting facilities, and expanded implementation to support more inclusive and meaningful English learning.

Documentation studies were conducted by reviewing various learning documents at SLB Negeri Mempawah and SLB Negeri Rasau Jaya, including lesson plans/modules, media specifications, student portfolios, attendance records, facility inventories, and media usage logs. The analysis was carried out systematically to assess the alignment between instructional design, implementation, and students' learning experiences, and was used as triangulation data to strengthen findings from observations and interviews.

Table 6. Findings from the Documentation Study

Nu	Aspect	Main Findings (SLB Mempawah vs SLB Rasau Jaya)	Description
1	Multisensory Strategy (Lesson Plan)	Mempawah: clearly integrated; Rasau Jaya: beginning to integrate	Implementation is not yet evenly distributed
2	Inclusive Learning Objectives	Both schools include non-visual learning access	Already adaptive
3	Audio Features of the Media	Both include pronunciation and sentence examples	Main features are available
4	Audio Settings	Mempawah: more adaptive; Rasau Jaya: still limited	Needs improvement
5	Student Portfolios	Both show increased vocabulary practice	Evidence of active engagement
6	Attendance and Participation	Mempawah: significantly increased; Rasau Jaya: gradually increased	Positive trend
7	Teacher Notes	Both recorded positive student responses	Validation of learning experiences
8	Facilities and Infrastructure	Mempawah: relatively more prepared; Rasau Jaya: limited	There is a facility gap
9	Technical Constraints	Both recorded minor disruptions	Not dominant
10	Mentoring Records	Strong teacher support; limited parental involvement	Home–school collaboration needs improvement
11	Documentation/Logs	Evidence of student–media interaction was visible	Strengthens data triangulation

Analysis of student portfolios, attendance records, and media usage logs shows increased student engagement in learning, marked by greater vocabulary practice, higher participation, and positive responses documented in teacher records. In terms of supporting facilities, SLB Negeri Mempawah is relatively more prepared than SLB Negeri Rasau Jaya, although both schools still face minor technical constraints and facility limitations. Documentation also reveals that teacher assistance plays a strong role in media implementation, while parental involvement still needs to be strengthened. Overall, the documentation study confirms that the AI-based Braille–audio media supports more inclusive, adaptive, and meaningful English learning while reinforcing observation and interview findings through data triangulation.

Data analysis was conducted gradually after all field data had been collected. During the transcription stage, the results of observations, interviews with students, teachers, principals, and documentation studies were transformed into complete written records. The next stage was data reduction, which involved selecting, focusing, and categorizing relevant information into major themes according to the research focus: perceptions, meaningful experiences, participation, and obstacles. The summarized data were then presented comparatively across the two research sites so that patterns, tendencies, and differences could be clearly identified. Based on this presentation, the researcher drew thematic conclusions representing the core meanings of the experience of using the AI-based Braille–audio dictionary in English learning.

Table 7. Thematic Analysis Results

Nu	Thematic Aspect	Main Findings (SLB Negeri Mempawah vs SLB Negeri Rasau Jaya)	Description
1	Data Transcription	Observation, interview, and documentation data showed consistent findings in both schools	Basis for thematic analysis
2	Data Reduction: Perceptions	Mempawah accepted the media more quickly; Rasau Jaya showed positive responses with initial adaptation	Informants' perceptions were consistent
3	Data Reduction: Meaningful Experiences	Braille–audio integration facilitated comprehension; Mempawah was more stable	Dominant theme
4	Data Reduction: Participation	Mempawah showed stronger improvement; Rasau Jaya improved gradually	Supported by various data sources
5	Data Reduction: Obstacles	Minor barriers related to audio, devices, and facilities; Rasau Jaya had more limited facilities	Real but non-dominant obstacles
6	Data Presentation: Multisensory Learning	Braille and audio complemented each other in understanding English	Cross-data pattern
7	Data Presentation: Affective Aspect	Enthusiasm, comfort, and self-confidence increased	Supported by observations and interviews
8	Data Presentation: Autonomy	Mempawah students were more independent; Rasau Jaya students still needed assistance	Influenced by media readiness
9	Institutional Support	Both schools supported innovation; Mempawah was more prepared for implementation	Difference in school readiness
10	Thematic Conclusion	The AI-based Braille–audio dictionary is effective, accessible, and meaningful	Worth developing further

The results of the data analysis indicate that the use of an Artificial Intelligence (AI)-based audio-integrated Braille dictionary provides positive and meaningful learning experiences for visually impaired students at SLB Negeri Mempawah and SLB Negeri Rasau Jaya. The data transcription stage demonstrated consistency among observation, interview, and documentation findings, forming a strong basis for thematic analysis. During the data reduction stage, students, teachers, and principals expressed positive perceptions of the media, although SLB Negeri Rasau Jaya required a more gradual adaptation process compared to SLB Negeri Mempawah. The integration of Braille and audio emerged as the dominant theme because it effectively facilitated vocabulary comprehension, enhanced meaningful learning experiences, and strengthened student engagement in English learning.

The analysis also revealed improvements in affective aspects, including enthusiasm, comfort, and self-confidence, accompanied by increased learning participation and greater independence in using the media, particularly at SLB Negeri Mempawah, which demonstrated better implementation readiness. Although minor obstacles related to facilities, devices, and audio tempo settings were still identified, these challenges did not become major barriers to learning. Institutional support from both schools also strengthened media implementation. Overall, the thematic

analysis confirms that the AI-based Braille–audio dictionary is effective, accessible, and meaningful in supporting inclusive English learning and is worthy of broader development.

DISCUSSION

The findings of this study indicate that the integration of an AI-based Braille–audio dictionary contributes positively to visually impaired students' English learning, particularly in improving vocabulary acquisition, pronunciation, comprehension, and student participation. These results are consistent with previous studies emphasizing that multisensory learning media combining tactile and auditory input can enhance accessibility and language comprehension for visually impaired learners (Rossiani et al., 2022; Furwasyih et al., 2022). The emergence of increased engagement, learning independence, and emotional comfort among students also supports prior findings that assistive technologies can strengthen motivation and participation in inclusive learning environments (Setiawan et al., 2023; Widodo et al., 2024).

However, despite these positive outcomes, the findings should be interpreted with caution. First, the effectiveness of the AI-based Braille–audio dictionary may be influenced by contextual factors specific to SLB Negeri Mempawah and SLB Negeri Rasau Jaya, such as teacher readiness, availability of assistive devices, and institutional support. The relatively better implementation observed in SLB Negeri Mempawah suggests that school infrastructure and teacher familiarity with technology play a significant role in shaping student experiences. Therefore, the results cannot be generalized broadly to all inclusive education settings in Indonesia without considering variations in resources and pedagogical capacity.

Second, this study also acknowledges potential researcher bias due to the phenomenological design, where the researcher acted as the primary instrument in data collection and interpretation. Although triangulation with students, teachers, parents, principals, and documentation was conducted, the interpretation of lived experiences remains subjective and influenced by the researcher's perspective. In addition, the reliance on self-reported experiences during interviews may introduce response bias, particularly in capturing emotional and motivational aspects of learning.

Third, while the study identifies improvements in cognitive, affective, and participatory aspects, the analysis remains largely descriptive and does not fully measure long-term learning outcomes or academic achievement. The short duration of fieldwork also limits the ability to assess sustained effects of AI-based Braille–audio integration on English language proficiency. Furthermore, technical limitations such as audio pacing, device accessibility, and occasional operational issues indicate that the technology is not yet fully optimized for all learners, particularly those requiring individualized adaptation.

From a theoretical perspective, the findings can be interpreted through multisensory learning theory and participation theory, which emphasize that learning becomes more effective when multiple sensory channels are engaged and when learners are actively involved in the learning process. In this study, the integration of Braille (tactile input) and AI-based audio (auditory input) demonstrates how multisensory stimulation can support meaning-making processes in second language acquisition. However, the findings also suggest that technology alone is not sufficient; pedagogical mediation by teachers remains essential to ensure meaningful learning experiences.

Overall, while the AI-based Braille–audio dictionary shows strong potential as an inclusive learning innovation, its effectiveness is context-dependent and should not be interpreted as universally applicable without further validation in different educational settings. Future research is needed to examine its long-term impact, scalability, and adaptability across diverse inclusive education environments, as well as to address technical optimization and pedagogical integration more comprehensively.

CONCLUSION

This study indicates that the AI-based Braille dictionary integrated with audio provides meaningful benefits for visually impaired students in English learning at SLB Negeri Mempawah and SLB Negeri Rasau Jaya. The integration of Braille and audio supports more effective vocabulary understanding, pronunciation practice, and contextual comprehension, while also contributing to more accessible and engaging learning experiences. In addition, students showed improvements in learning motivation, confidence, participation, social interaction, and gradual development of learning independence. However, these positive outcomes should be interpreted in light of several limitations. The effectiveness of the media is influenced by technical factors such as audio pacing and device stability, as well as institutional factors including infrastructure availability and teacher readiness. These conditions indicate that the success of AI-based assistive learning media depends not only on its technological design but also on contextual and pedagogical support within inclusive education settings.

Theoretically, this study contributes to the understanding of multisensory learning by demonstrating how the integration of tactile (Braille) and auditory (AI-based audio) modalities supports meaning-making processes in English language learning for visually impaired students. Practically, the findings highlight the importance of adaptive learning media design that aligns with students' sensory needs and classroom realities. This study also has limitations in terms of scope, as it was conducted in only two special schools with a limited number of participants and a short observation period. Therefore, the findings cannot be generalized broadly to all inclusive education contexts. Future research is recommended to explore the long-term impact of AI-based Braille-audio media on students' English proficiency, to test its effectiveness in broader educational settings, and to further refine its technical features such as adaptive audio speed, personalized learning settings, and offline functionality to better support diverse learner needs.

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