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Eduvocal "Nderes": Developing an Accessible Slendro Vocal Learning E-Book for Visually Impaired Children

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Abstract: This study aims to design and develop an audio-based vocal learning medium in the slendro tuning system for visually impaired elementary school students in the form of the Eduvocal "Nderes" e-book. The development of this medium was motivated by the limited availability of accessible karawitan learning media for visually impaired learners, particularly in traditional Javanese vocal instruction. The product was designed by considering auditory learning needs through tiered vocal materials, audio instructions, repetitive exercises (nderes), and compatibility with screen-reader technology. This study employed a Research and Development (R&D) approach using the Borg and Gall development model, which includes stages of needs analysis, product design, expert validation, product revision, and limited product trials. The needs analysis was conducted through questionnaires distributed to 16 respondents consisting of visually impaired individuals, parents, teachers, karawitan practitioners, and peers. Product validation involved media experts, karawitan experts, and special education experts specializing in visual impairment. The validation results showed a feasibility score of 93.21%, categorized as highly feasible. Furthermore, limited product trials involving six respondents obtained a score of 86.3%, categorized as very good. The findings indicate that the Eduvocal "Nderes" e-book prototype is appropriate for use as an accessible vocal learning medium for visually impaired students at the elementary school level. This study contributes to the development of inclusive digital learning media while supporting the preservation of traditional Javanese musical culture for learners with visual impairments.

Keywords: e-book, visually impaired students, slendro tuning system, karawitan vocal learning, accessible learning media

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Introduction

Inclusive education in Indonesia has shown significant progress in recent years. According to data from the Coordinating Ministry for Human Development and Culture, by September 2023 approximately 44,477 regular schools had implemented inclusive education programs, increasing from 35,802 schools in 2021. Nevertheless, substantial challenges remain in ensuring equal access and quality educational services for students with disabilities. Data from the Ministry of Education, Culture, Research, and Technology indicate that access to inclusive education for individuals with disabilities has only reached around 52%, demonstrating that disparities in educational accessibility continue to exist (Kemenko PMK, 2023; Kemendikbudristek,

2023). This condition aligns with UNESCO's report emphasizing that educational inclusion remains a global challenge, particularly in providing equitable and high-quality learning opportunities for all learners. (UNESCO, 2020)

Education is a fundamental right of every child, including children with special needs. Among students with disabilities, visually impaired children experience various challenges in accessing learning materials and participating in educational activities (Praptaningrum, 2020a). In the learning process, visually impaired students rely primarily on their remaining functional senses, especially hearing and touch. Consequently, auditory ability plays a central role in supporting their academic development. However, auditory skills do not develop automatically and require systematic training and appropriate instructional support. Therefore, auditory-based learning approaches are highly relevant in facilitating meaningful learning experiences for visually impaired students.

The rapid development of digital technology has created new opportunities to support inclusive education through accessible learning media, one of which is the use of e-books. Compared to conventional printed books, e-books provide greater accessibility because they can be integrated with screen-reader technology, audio features, and interactive multimedia components (Alper & Raharinirina, 2006; Mayer, 2002). Such features enable visually impaired students to access learning materials more independently and efficiently. (Adinda Kadwi L.P et al., 2024).Previous studies have shown that assistive technology significantly improves participation and academic engagement among visually impaired learners in inclusive classrooms. (Ketema Dabi & Negassa Golga, 2024; Tuttle & Carter, 2024).Furthermore, e-books allow users to customize navigation systems, audio settings, and learning interfaces according to individual needs, thereby increasing flexibility and accessibility in the learning process.

Recent studies have also demonstrated that interactive digital learning media can improve learning engagement, conceptual understanding, and independent learning among students with special needs(Tenorio-Sepúlveda et al., 2023). The integration of Information and Communication Technology (ICT) into educational practice has expanded access to learning resources while strengthening educational inclusivity (Mnyanyi, 2023; Nanga, 2025). In addition, e-books are considered more practical and sustainable because they reduce printing and distribution costs and can easily be updated according to users' needs (Arsyad, 2013). The development of artificial intelligence and assistive technologies has further broadened opportunities for supporting visually impaired learners (Abadi et al., 2025)and strengthening the implementation of inclusive education in various educational contexts. (Gidisu et al., 2026)

Despite these technological advancements, learning media specifically designed for visually impaired students in the context of traditional Javanese vocal

learning remain limited. Existing learning media are generally developed for broader educational purposes and do not fully accommodate the auditory characteristics, accessibility needs, and pedagogical approaches required by visually impaired learners. In particular, accessible learning media focusing on vocal instruction within the slendro tuning system are still rarely available. This condition indicates a gap between the learning needs of visually impaired students in traditional vocal arts education and the availability of contextual, adaptive, and accessible instructional media.

In response to this issue, the development of the Eduvocal "Nderes" e-book is proposed as an innovative and inclusive learning medium for visually impaired children. The product is specifically designed to support vocal learning within the slendro tuning system through an auditory-based instructional approach. In addition to improving learning accessibility, the media is expected to encourage greater participation of visually impaired students in inclusive arts education while simultaneously contributing to the preservation of traditional Javanese musical culture.

Karawitan vocal learning was selected as the focus of this study because its instructional characteristics are strongly auditory-oriented, making it suitable for visually impaired learners. The slendro tuning system was specifically chosen because of its pentatonic tonal structure, which is relatively simple and easier for beginner learners to recognize and imitate. This selection is based not only on pedagogical considerations but also on cultural considerations, as slendro constitutes an important element of Javanese karawitan tradition and represents an essential component of Indonesia's cultural heritage.

Preliminary observations and interviews conducted with parents, teachers, companions of visually impaired children, and individuals involved in karawitan education revealed that accessible and contextual learning media are urgently needed. Respondents emphasized the importance of learning media that are easy to access, simple to operate independently, and suitable for the auditory learning characteristics of visually impaired children. These findings highlight the urgent need of developing accessible and structured learning media specifically designed for traditional vocal instruction.

The term "Nderes" in Javanese learning culture refers to repetitive recitation or repeated oral practice conducted continuously to facilitate memorization and comprehension. In educational contexts, repetitive auditory exercises are widely recognized as effective strategies for strengthening listening skills and vocal imitation. Therefore, the concept of nderes was adapted in the development of the Eduvocal "Nderes" e-book as an instructional approach emphasizing repetition, gradual listening practice, and independent auditory learning for visually impaired students.

The novelty of this study lies in the integration of three main aspects within a single educational product: (1) repetitive auditory learning based on the nderes approach, (2) accessible digital technology compatible with screen-reader systems, and (3) traditional Javanese vocal learning material based on the slendro tuning system. Unlike previous studies that generally focus only on audio learning media or assistive technology in general education, this study specifically develops an accessible karawitan vocal learning medium designed for visually impaired elementary school students. Therefore, this study contributes not only to inclusive education and instructional media development but also to the preservation and accessibility of traditional Javanese musical culture.

Based on this background, this study aims to develop the Eduvocal "Nderes" e-book as an accessible vocal learning medium based on the slendro tuning system for visually impaired elementary school students. This study employs the Research and Development (R&D) approach using the Borg and Gall development model, which systematically includes stages of needs analysis, product design, expert validation, product trials, and product revision in order to produce a feasible and accessible educational medium.

Methodology

This study employed the Research and Development (R&D) method, which is widely used in educational research to develop and evaluate instructional products systematically. The R&D approach aims not only to produce a particular educational product but also to examine the feasibility and effectiveness of the product in practical learning contexts (Sugiyono, 2015). According to Walter R. Borg and Meredith D. Gall, the R&D method integrates product development procedures with empirical testing in order to generate educational products that are valid, practical, and effective (Assyauqi, 2020a; Borg & Gall, 1984). The development model adopted in this study referred to the Borg and Gall model, which originally consists of ten stages. However, in this study, the stages were simplified into seven stages according to the scope and needs of the research (Assyauqi, 2020) The stages of the research and development process consisted of:

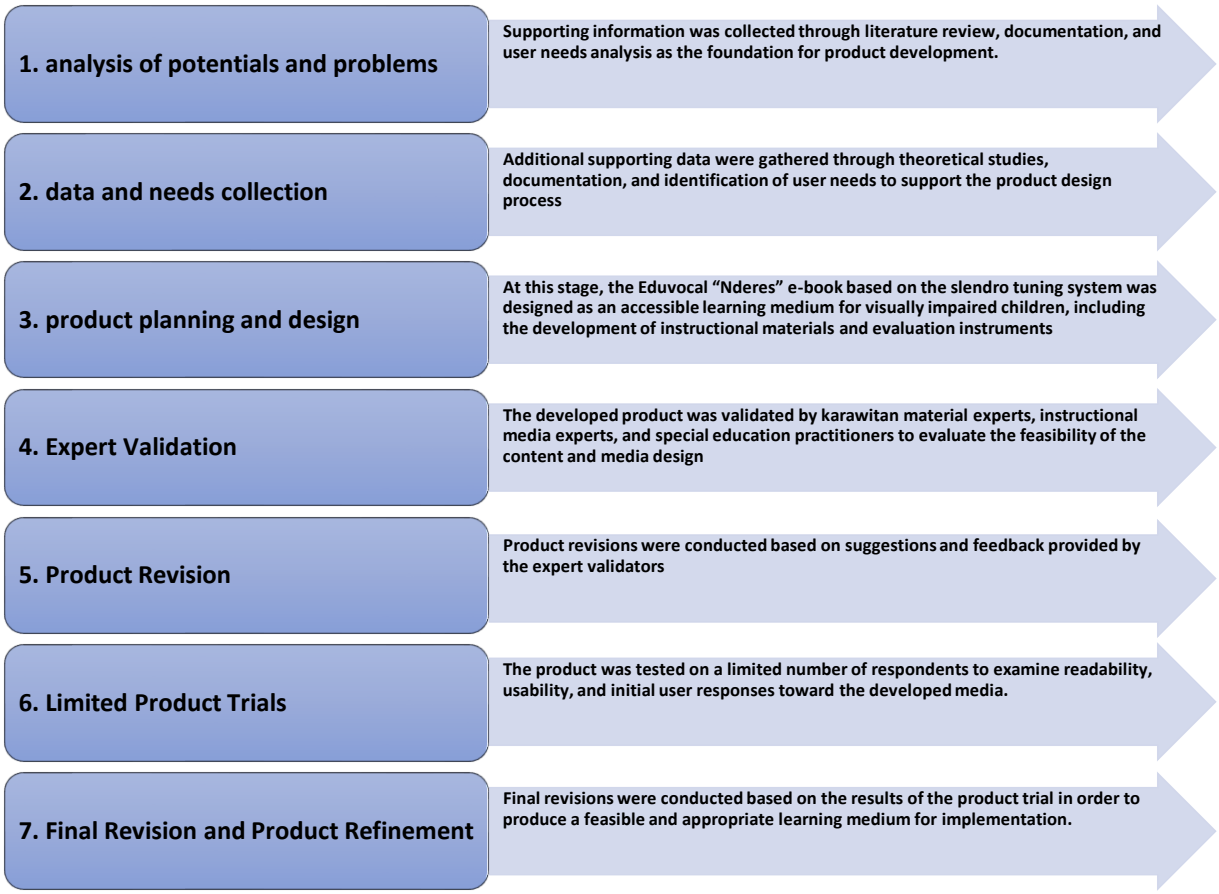


Figure 1. Product/Learning Media Development Stages

The product developed in this study was the Eduvocal "Nderes" e-book prototype, an audio-based learning medium designed to support vocal learning within the slendro tuning system for visually impaired elementary school students. The product was developed to address the limited accessibility of karawitan vocal learning media available for visually impaired learners.

This research was conducted in Surakarta over a six-month period. The research participants consisted of visually impaired individuals, parents, teachers, karawitan practitioners, observers, and peers involved in the learning process. The selection of participants was intended to obtain comprehensive information related to user needs, media accessibility, product feasibility, and instructional effectiveness.

Data collection constituted an important stage in the product development process. Several techniques were employed, including questionnaires, observations, interviews, and documentation. According to Arikunto (Arikunto, 2013), data collection techniques are essential procedures used to obtain accurate and relevant research data.

Questionnaires were used as the primary instrument for collecting quantitative data from respondents. (Sugiyono, 2009) explains that questionnaires are data

collection instruments consisting of written statements or questions distributed to respondents to obtain information systematically. In this study, questionnaires were used during the validation and product trial stages to evaluate product feasibility, accessibility, usability, and instructional quality.

Observation techniques were also employed to examine participant behavior and responses during the product trial process. Observation, according to (Sugiyono, 2009), involves systematic processes of observing and recording phenomena occurring during research activities. In this study, non-participant observation was conducted, meaning that the researchers acted solely as observers without direct involvement in learning activities.

Documentation techniques were utilized to support the research findings through photographs, screenshots, and records related to product development and trial implementation. Documentation served as supporting empirical evidence throughout the research process.

Structured interviews were conducted with media experts, karawitan experts, special education experts, and product users to obtain deeper qualitative information regarding product accessibility, instructional quality, usability, and technical performance. Interview guidelines were developed systematically based on aspects related to learning content, media accessibility, and user experience.

The data obtained from questionnaires were analyzed quantitatively using descriptive statistical analysis. The assessment instruments employed a Likert scale with a score range from 1 to 5, ranging from very poor to very good. According to (Sugiyono, 2009), the Likert scale is widely used to measure attitudes, perceptions, opinions, and responses toward particular phenomena.

Product feasibility was calculated using percentage analysis by comparing the obtained score with the maximum possible score and multiplying the result by 100%. The feasibility criteria applied in this study were categorized as follows:

81–100% = highly feasible,
61–80% = feasible,
41–60% = moderately feasible,
21–40% = less feasible, and
0–20% = not feasible.

Product validation was conducted by involving media experts, karawitan experts, and special education experts specializing in visual impairment education. According to (Sugiyono, 2015), expert validation is an important stage in product development research because it enables researchers to identify strengths and weaknesses before wider implementation.

Following the validation stage, limited product trials were conducted involving six respondents consisting of visually impaired individuals, observers, and peers. The trials aimed to examine product usability, accessibility, and user responses in practical learning situations. Data collection during the trial stage was conducted through questionnaires and direct observation. The product testing process in this study also aligns with the concept proposed by Roger S. Pressman, who states that testing is conducted to identify weaknesses and evaluate product performance before implementation in broader contexts (Pressman, 2005)

Through this systematic development process, the study aimed to produce an accessible Eduvocal "Nderes" e-book prototype suitable for supporting vocal learning within the slendro tuning system for visually impaired elementary school students while contributing to inclusive education and the preservation of traditional Javanese musical culture.

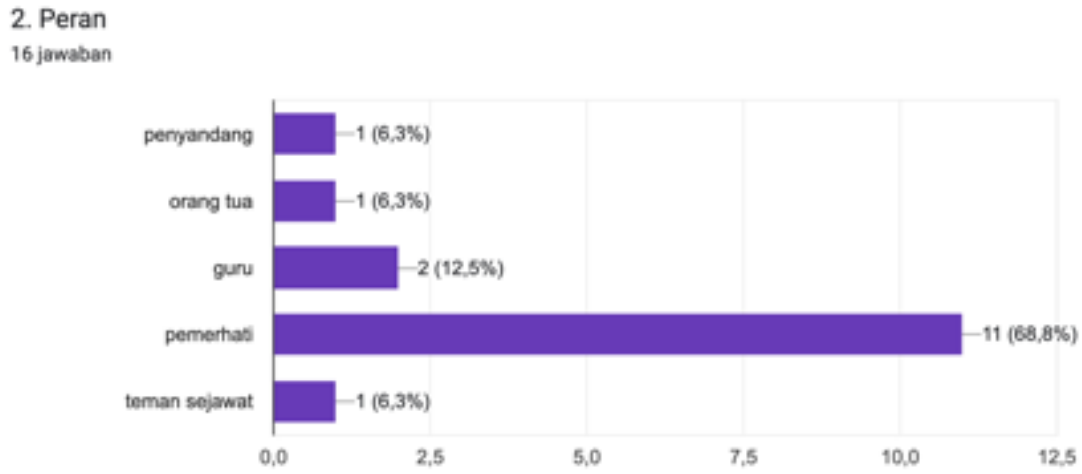
Results and Discussion

Results

This study produced an audio-based learning medium in the form of the Eduvocal "Nderes" e-book prototype designed for visually impaired elementary school students in learning vocal techniques within the slendro tuning system. The findings are presented according to the stages of the Borg and Gall development model, including needs analysis, product planning, expert validation, product revision, product trials, and final product refinement.

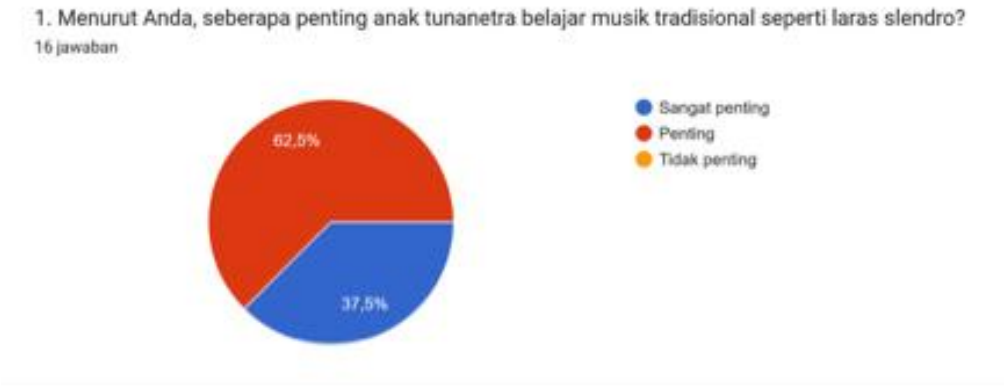
1. Needs Analysis

At the initial stage of development, the study focused on identifying the learning needs and challenges experienced by visually impaired learners in karawitan vocal instruction. In this stage, Visually impaired children were not directly involved during the preliminary needs-analysis stage. Instead, information was collected from parents, teachers, companions, karawitan practitioners, observers, and individuals experienced in assisting visually impaired learners. This approach aimed to obtain a comprehensive understanding of learner characteristics, instructional needs, and accessibility challenges in traditional vocal learning contexts. Data collection was conducted through questionnaires distributed using Google Forms to 16 respondents from diverse backgrounds, including visually impaired individuals, parents, teachers, karawitan observers, and peers.



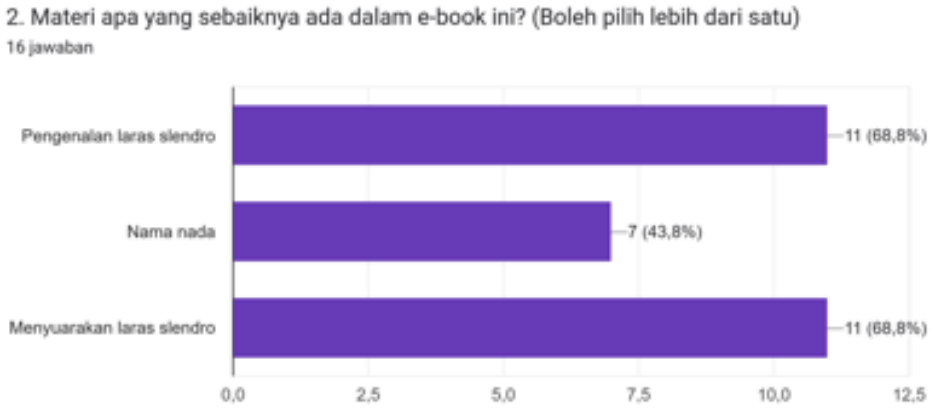
The needs analysis revealed several important findings. First, visually impaired students experience difficulties in learning vocal materials within the slendro tuning system due to the limited availability of accessible and systematic auditory learning media. In many learning situations, karawitan instruction is still conducted through direct demonstration using gamelan instruments, whereas not all schools possess adequate gamelan facilities or qualified karawitan instructors.

Second, teachers emphasized the importance of audio-based learning media that are easy to access, systematically organized, and capable of supporting independent practice. Third, karawitan practitioners highlighted the importance of clear and accurate audio recordings to facilitate tonal recognition and vocal imitation among visually impaired learners. Most respondents also agreed that introducing slendro tonal concepts is important in karawitan learning because auditory sensitivity constitutes the primary learning modality of visually impaired students.



These findings demonstrate the urgent need for accessible and auditory-oriented instructional media specifically designed for visually impaired learners in traditional vocal education.

2. Product Planning and Design



Based on the results of the needs analysis, the researchers designed an audio-based e-book prototype with a progressive and structured learning system. The instructional materials were organized gradually, beginning with the introduction of basic tones in the slendro tuning system and continuing toward simple vocal exercises.

The product incorporated several main components, including:

1. audio instructions,
2. vocal demonstrations,
3. repetitive listening and imitation exercises,
4. simple navigation systems, and
5. accessibility features compatible with screen-reader applications.

The instructional structure adopted the nderes approach, emphasizing repetitive auditory practice as a strategy for strengthening listening comprehension and vocal imitation skills. This approach aligns with auditory learning principles emphasizing repetition and gradual listening practice as effective methods for visually impaired learners (Praptaningrum, 2020a).

Because the product was intended for elementary school students, children's voices were used in the audio recordings to create learning experiences appropriate to the characteristics of the target users. The product was developed in MP3 audio format to ensure accessibility across various digital devices commonly used by visually impaired students.

The navigation design was intentionally simplified to improve usability and accessibility. Particular attention was given to screen-reader compatibility to enable users to independently access the learning materials. This approach is consistent with previous studies emphasizing the importance of assistive technology and accessible digital media in inclusive learning environments (Alper & Raharinirina, 2006)

3. Expert Validation

After the product prototype had been developed, expert validation was conducted to assess the feasibility and quality of the Eduvocal "Nderes" e-book before implementation in user trials. The validation process involved: media and technology experts, karawitan experts, and special education experts specializing in visual impairment education.

The validation instrument consisted of three main assessment aspects:

Table 1. Expert Team Assessment Aspect

No	Assessment Aspect	Number of Items
1	Content Feasibility	5
2	Media Display and Accessibility	5
3	Instructional Quality	4
	Total	14 Items

The assessment employed a Likert scale ranging from 1 to 5 to obtain quantitative feasibility data (Sugiyono, 2015)

Table 2. Validator Assessment Results

No.	Validator	Expertise	Experience	Total Score	Maximum Score	Percentage	Category
1	Anantha Angriany Sitio, S.Sn., M.Sn.	Media and IT Expert	1 year	68	70	97.14%	Highly Feasible
2	Sigit Setiawan, S.Sn., M.Sn.	Karawitan Expert	2 years	61	70	87.14%	Highly Feasible
3	Tika Puspita Sari, S.Pd., M.Sn.	Special Education Expert	3 years	67	70	95.71%	Highly Feasible
4	Leny Nur Ekasari, S.Sn., M.A.	Karawitan Expert	1 year	65	70	92.85%	Highly Feasible
	Total			**261**	**280**	**93.21%**	**Highly Feasible**

Table 3. Expert Feedback and Suggestions

No.	Validator	Suggestions and Feedback
1	Anantha Angriany Sitio, S.Sn., M.Sn.	Pages 8–15 were considered less compatible with screen-reader applications due to the use of boxed layouts and multiple-column formatting.
2	Sigit Setiawan, S.Sn., M.Sn.	The organization of learning materials should be arranged more systematically to support gradual vocal learning in the *slendro tuning system*.
3	Tika Puspita Sari, S.Pd., M.Sn.	The product would benefit from the addition of materials related to the *pelog tuning system* for beginner-level learners.
4	Leny Nur Ekasari, S.Sn., M.A.	The media was considered highly beneficial for visually impaired students in learning karawitan vocals.

The validation results showed that the product obtained a total score of 261 out of a maximum score of 280, resulting in a feasibility percentage of 93.21%, categorized as highly feasible. These findings indicate that the Eduvocal "Nderes" prototype is appropriate for use as an accessible learning medium for visually impaired students.

In addition to quantitative evaluation, validators also provided several suggestions for improvement. Media experts noted that several pages were less compatible with screen-reader applications because of column-based layouts and boxed formatting. Karawitan experts suggested improving the systematic organization of the vocal materials. Special education experts recommended the future addition of materials related to the pelog tuning system to support beginner learners in recognizing tonal variations. Overall, the validators considered the product highly beneficial for supporting inclusive karawitan vocal learning among visually impaired students.

4. Product Trials

Following revisions based on expert feedback, limited product trials were conducted involving six respondents consisting of visually impaired individuals, observers, and peers. The trial stage aimed to examine the usability, attractiveness, and instructional benefits of the product in practical learning situations.

The user response instrument evaluated three main aspects:

Table 4. Respondent Assessment Aspect

No.	Assessment Aspects	Number of Items
1	Ease of Use	4
2	Media Attractiveness	3
3	Instructional Benefits	3
	Total	**10 Items**

The following are the results of user responses to the Eduvocal "Nderes"

Table 5. User Responses toward the Eduvocal "Nderes" Product

No.	Respondent	Respondent Category	Experience	Total Score	Maximum Score	Percentage	Category
1	R1	Observer	None	47	50	94%	Excellent
2	R2	Visually Impaired Participant	Visually impaired	41	50	82%	Excellent
3	R3	Peer	2 years	46	50	92%	Excellent
4	R4	Observer	3 years	45	50	90%	Excellent
5	R5	Visually Impaired Participant	Blind since childhood	32	50	64%	Good
6	R6	Observer	No prior experience	48	50	96%	Excellent
	Total			**259**	**300**	**86.3%**	**Very Good**

Table 6. Results of Comments and Suggestions

No.	Respondent	Comments and Suggestions
1	R1	The product was considered highly effective in supporting vocal learning within the *slendro tuning system*.
2	R2	The media was considered easy to use and accessible for visually impaired users.
3	R3	The product was considered to have a sufficiently structured learning system for independent practice.
4	R4	Several e-book pages were still less compatible with screen-reader applications due to column-based layouts. Additional audio navigation instructions were also recommended.
5	R5	The media was considered helpful and appropriate for supporting vocal learning activities among visually impaired students.
6	R6	Introductory explanations and additional learning materials should be expanded to improve user understanding.

The trial results demonstrated that the product obtained a total score of 259 out of a maximum score of 300, resulting in a percentage score of 86.3%, categorized as very good. These findings indicate that the Eduvocal "Nderes" e-book is considered feasible and beneficial as a learning medium for visually impaired learners.

Respondents generally stated that the product: facilitated independent learning, improved accessibility to karawitan vocal materials, assisted tonal recognition and vocal imitation, and supported repetitive auditory practice. Several respondents also provided suggestions for improvement, including: simplifying page layouts to improve screen-reader accessibility, adding clearer audio navigation instructions, expanding introductory learning materials, and improving the organization of learning content.

Overall, users perceived the product as accessible, practical, and supportive of vocal learning activities among visually impaired students.

5. Product Revision and Finalization

The final revision stage was conducted based on feedback from both expert validators and trial participants. Revisions focused primarily on:

simplifying navigation systems, improving screen-reader compatibility, adjusting audio tempo, reorganizing learning materials more systematically, and refining the accessibility of several e-book pages.

Following the revision process, the final product was produced in the form of an accessible audio-based Eduvocal "Nderes" e-book prototype specifically designed to support vocal learning within the slendro tuning system for visually impaired elementary school students. The product integrates auditory learning strategies, repetitive listening exercises, and accessible digital media design to create an inclusive learning environment supporting both traditional arts education and educational accessibility for learners with visual impairments.

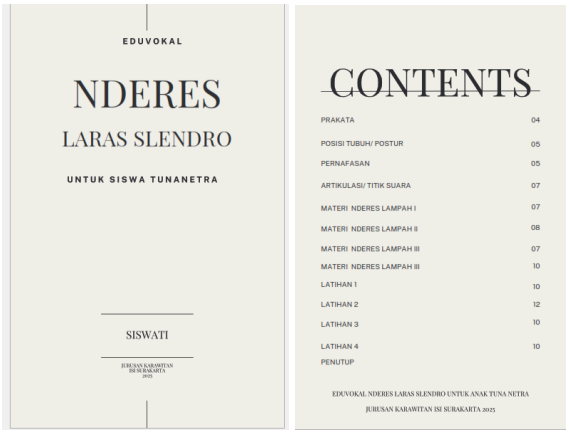


Figure 2. Final Product

Discussion

The findings of this study indicate that audio-based learning media are highly compatible with the learning characteristics of visually impaired students, who primarily rely on auditory perception in acquiring information and learning experiences. Unlike visual learning media, audio-based instructional media provide direct access through auditory modalities, which function as the dominant sensory channel for visually impaired learners. According to Richard E. Mayer, multimedia learning involving auditory elements can support information processing by optimizing learners' auditory cognitive channels(Mayer, 2002)

The implementation of the nderes approach in the learning design demonstrated strong potential in supporting tonal recognition and vocal imitation within the slendro tuning system. Through repetitive auditory exercises, students repeatedly listened to and imitated vocal patterns, thereby strengthening listening comprehension and pitch accuracy. The results of the limited product trial showed that users responded positively to the repetitive learning structure and perceived it as beneficial for independent vocal practice.

In terms of instructional quality, expert validation confirmed that the vocal materials were appropriate for beginner-level karawitan instruction and suitable for elementary school learners. The use of children's voices in the audio recordings further enhanced the relevance of the instructional materials to the characteristics of the target users.

The findings of this study are consistent with previous research conducted by Agnes Praptaningrum regarding the application of audio-based learning materials for visually impaired students in Indonesia. Previous studies demonstrated that auditory learning media effectively support visually impaired learners by maximizing hearing abilities as the primary modality for receiving instructional information (Praptaningrum, 2020b). Similarly, this study found that audio-based learning media facilitated understanding, repetition, and independent learning processes among visually impaired students.

However, this study differs from previous research in several important aspects. Earlier studies generally focused on the use of audio media in general educational contexts, whereas this study specifically developed an accessible karawitan vocal learning medium based on the slendro tuning system for visually impaired elementary school students. Moreover, this study integrated repetitive auditory learning principles (nderes), accessible digital media design, and traditional Javanese vocal instruction into a single educational product.

This study contributes theoretically to the discourse of inclusive arts education by demonstrating that auditory-based traditional music instruction can be transformed into accessible digital learning environments for visually impaired learners. The integration of repetitive auditory learning, accessibility-oriented media

design, and traditional Javanese vocal instruction expands current discussions regarding inclusive cultural pedagogy in digital education contexts.

From the perspective of accessibility in education, the development of Eduvocal "Nderes" also highlights the importance of digital accessibility in inclusive learning environments. The integration of simple navigation systems and screen-reader compatibility supports independent access to learning materials among visually impaired users. Previous studies have emphasized that assistive technologies play an essential role in improving educational participation and accessibility for individuals with disabilities (Alper & Raharinirina, 2006; Tuttle & Carter, 2024)

In the broader context of inclusive traditional arts education, this study demonstrates that karawitan learning can be adapted into more accessible instructional forms through auditory-based media development. The selection of the slendro tuning system was considered appropriate because of its relatively simple pentatonic tonal structure, which facilitates tonal recognition among beginner learners.

Karawitan vocal learning also represents an important component of Indonesia's intangible cultural heritage, making accessibility in traditional arts education increasingly relevant in contemporary inclusive education discourse. Therefore, the integration of accessible digital learning media into karawitan instruction not only supports educational inclusivity but also contributes to cultural preservation efforts among younger generations, including learners with visual impairments.

Therefore, the development of Eduvocal "Nderes" contributes not only to instructional innovation in inclusive education but also to the preservation of traditional Javanese musical culture. This study demonstrates that cultural education and accessibility can be integrated through digital learning media, thereby creating broader opportunities for students with disabilities to participate actively in traditional arts learning. Practically, the Eduvocal "Nderes" e-book may serve as an alternative instructional medium for schools lacking gamelan facilities, accessible vocal learning resources, or specialized karawitan instructors for visually impaired students.

Conclusion

This study successfully developed the Eduvocal "Nderes" e-book prototype as an audio-based vocal learning medium within the slendro tuning system for visually impaired elementary school students. The product was designed by considering the auditory learning characteristics of visually impaired learners and the need for accessible instructional media in karawitan vocal education.

The developed prototype possesses several main characteristics, including structured and gradual vocal learning materials, audio-based instructional guidance, repetitive listening and imitation exercises based on the nderes approach, accessible

MP3 audio format, and compatibility with screen-reader technology. These features enable the product to function not only as an independent learning medium for visually impaired students but also as a supporting instructional medium for teachers and learning companions in karawitan vocal education.

The expert validation results demonstrated that the product achieved a feasibility score of 93.21%, categorized as highly feasible. The assessment involved media experts, karawitan experts, and special education experts specializing in visual impairment education. Furthermore, limited product trials involving six respondents obtained a score of 86.3%, categorized as very good. These findings indicate that the Eduvocal "Nderes" e-book is considered appropriate and beneficial as an accessible learning medium for visually impaired learners.

Users responded positively to the product, particularly regarding ease of audio access, clarity of vocal materials, support for independent learning, and assistance in tonal recognition and vocal practice. Several suggestions for improvement were also identified, including simplifying page layouts to improve screen-reader accessibility, adding clearer audio navigation instructions, improving learning tempo adjustment, and expanding instructional materials for broader learning needs.

Although the study produced promising results, several limitations remain. The product development was conducted only at the prototype and limited-trial stages; therefore, the effectiveness of the media in improving student learning outcomes has not yet been experimentally measured. In addition, the number of trial participants was relatively limited, and the product has not yet been implemented in large-scale classroom settings.

Therefore, future studies are recommended to conduct experimental research on the effectiveness of the media, involve larger participant groups, improve compatibility across various screen-reader applications, develop additional materials based on the pelog tuning system, and integrate more interactive accessibility features within the e-book.

Overall, this study contributes to the development of inclusive learning media in traditional arts education while simultaneously supporting the preservation and accessibility of Javanese musical culture for students with visual impairments.

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