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The Development of Braille Scrabble Enhancing English Vocabulary Acquisition among Visually Impaired Students in Secondary Education

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ABSTRACT

The mastery of English vocabulary among visually impaired students is significantly hindered by a heavy reliance on audio-based assistive technology, which often fails to reinforce structural spelling and orthographic understanding. This reliance creates a persistent literacy gap that affects their overall language proficiency. This study aims to develop a multisensory Scrabble Braille learning media and to evaluate its feasibility, practicality, and effectiveness in enhancing vocabulary acquisition for secondary students. Following the Research and Development (R&D) approach with the ADDIE model, the research was conducted at SMK N 8 Surakarta and MAN 2 Sleman, involving six visually impaired participants. Data were collected through expert validation, pretests, posttests, and user questionnaires. Results indicate that the media is highly feasible, with material and media validation scores reaching 97.5% and 93.75%, respectively. Practicality tests conducted by teachers and students yielded "Very Good" ratings, highlighting ease of use and increased motivation. Furthermore, the media proved effective as average student scores rose significantly from 4.83 to 8.33. This innovation provides an inclusive, dual-access solution that bridges the literacy gap between visually impaired and sighted learners while fostering independent learning.

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1. INTRODUCTION

Vocabulary mastery is a fundamental element of English language acquisition; without it, students struggle to comprehend texts and express ideas effectively [1]. For visually impaired students, this challenge is compounded by the lack of visual access to learning materials [2]. Observations at SMK N 8 Surakarta and MAN 2 Sleman reveal that, while these students frequently use audio-based technologies such as screen readers, they often lack proficiency in Braille and exhibit poor spelling skills. This reliance on audio-only

technology creates a literacy gap, as it fails to reinforce the structural and orthographic understanding of words. Consequently, Braille-based tactile media remains essential for establishing foundational literacy and grasping the relationship between sounds and symbols. Consequently, Braille-based media remains essential for establishing foundational literacy and grasping the relationship between sounds and symbols [3] [4]. Game-based learning, such as Scrabble, offers a tactile and interactive approach to spelling and word construction [5]. However, existing Braille Scrabble media often fail to meet the principles of Universal Design for Learning (UDL), limiting their effectiveness in inclusive classrooms. This study develops an enhanced version of Braille Scrabble by integrating printed letters and audio barcodes. This multisensory innovation is designed to bridge the gap between visually impaired and sighted students, fostering collaboration and boosting confidence through inclusive, adaptive, and engaging vocabulary learning.

Game-based learning, specifically through Scrabble, provides students with immediate opportunities to construct words, practice spelling, and self-correct errors. For visually impaired students, such games must be modified for tactile accessibility [6]. This adaptation transcends technical adjustments; it serves a crucial psychological function by fostering a sense of equality between visually impaired students and their sighted peers. While Braille Scrabble has been developed to facilitate active English vocabulary acquisition [7], many existing versions fail to fully align with the principles of Universal Design for Learning (UDL). These shortcomings often result in media that remain exclusive and difficult to use collaboratively within inclusive classrooms. True educational innovation must prioritize the needs of the most vulnerable learners to prevent further marginalization.

Previous studies have developed Braille Scrabble to facilitate English vocabulary acquisition, but most existing versions focus exclusively on tactile elements for the blind. This creates a barrier in inclusive classrooms where visually impaired students and sighted peers cannot interact using the same tool. Many existing media fail to align with the principles of Universal Design for Learning (UDL), making the learning process remains exclusive. To bridge this gap, this research introduces an enhanced Braille Scrabble that integrates three sensory elements: tactile Braille, visual printed letters, and audio barcodes. This dual-access design ensures the media is usable by both visually impaired and sighted students, creating a collaborative and equitable learning space.

The development of this multisensory media is grounded in the Dual Coding Theory, which suggests that information is better retained when processed through both verbal (audio) and non-verbal (tactile/visual) channels. Furthermore, it applies the Multisensory Teaching approach, engaging touch, sight, and hearing to stimulate cognitive and motor engagement in students. This research introduces an enhanced Braille Scrabble media integrated with printed letters (visual text) and audio barcodes. This dual-access design ensures the media is usable by both visually impaired and sighted students, creating a collaborative and equitable learning space [8]. Beyond linguistic gains, this multisensory approach strengthens social bonds as sighted students gain a deeper understanding of the challenges faced by their peers. By engaging touch, sound, and sight, this media aims to improve vocabulary retention, pronunciation, and spelling accuracy. Ultimately, this study

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seeks to realize genuine inclusion by providing visually impaired students with a learning tool that is not only adaptive but also psychologically empowering and engaging.

2. METHOD

This study employed the Research and Development (R&D) method following the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as proposed by Branch (2010) [9]. The process began with an analysis of learning media needs for visually impaired students, followed by the conceptual design of Braille Scrabble, product development, implementation through field testing, and a final evaluation of its effectiveness. The research was conducted at two inclusive secondary schools, SMK Negeri 8 Surakarta and MAN 2 Sleman, which were selected based on their facilities and relevance to the media's characteristics. Using a purposive sampling technique [10], the subjects involved six 11th-grade students with visual impairments, consisting of four students with total blindness and two with low vision, along with their respective subject teachers.

Data collection was carried out through semi-structured interviews during the analysis phase to identify learning barriers, followed by the distribution of questionnaires to material and media experts for product validation. Furthermore, practicality questionnaires were administered to teachers and students during the implementation phase, while pretests and posttests were used in the evaluation stage to measure the media's impact on English vocabulary mastery. Data analysis integrated both qualitative and quantitative approaches; qualitative data from interviews and expert feedback informed product revisions, while quantitative descriptive analysis was used to calculate Likert-scale percentages for feasibility and practicality. Finally, the media's effectiveness was determined by calculating the gain score from pretest and posttest results, with a significant increase serving as the primary indicator of the media's success in enhancing students' linguistic skills.

3. RESULTS

The interview analysis revealed that visually impaired high school students have distinct needs in English language learning, particularly regarding vocabulary acquisition. Both teachers and students emphasized that while audio-based learning is beneficial, it requires supplementary tactile media, such as Braille, to optimize learning. The integration of audio and Braille is believed to facilitate a simultaneous understanding of word meaning, pronunciation, and spelling [11]. Furthermore, thematic materials closely related to daily life, such as "School Life," were found to be more relevant and accessible. These findings underscore the critical importance of a multisensory approach in language instruction for students with visual impairments.

Moreover, teachers highlighted a significant gap in the availability of game-based learning media specifically designed for visually impaired learners. Most existing media are generic and lack essential accessibility features, forcing students to rely heavily on teacher explanations that often fail to provide active learning experiences [12]. This limitation also restricts students' opportunities for independent study outside of classroom hours. Consequently, there is an urgent need for innovative media that accommodates sensory requirements while offering an engaging learning experience. The interviews further

indicated that students are more motivated when learning through play, as it reduces boredom and fosters natural vocabulary acquisition. Teachers noted that this method enhances peer interaction and supports collaborative learning [12].

From a technical perspective, educators recommended that the developed media feature a practical design accessible to both visually impaired and sighted students. This includes standardized Braille sizing, clear audio quality, and durable materials. The integration of barcodes connecting words to audio pronunciation was identified as an effective solution for supporting autonomous learning [13]. By combining inclusive design with supportive technology, the proposed media serves as a potent tool for enhancing English vocabulary mastery. These comprehensive findings establish a solid foundation for the product design phase, ensuring the media aligns with users' authentic needs in the field.

3.1. The Design of Braille Scrabble Media

The design of the Braille Scrabble media was developed based on the principles of Universal Design for Learning (UDL) and a multisensory approach. This media is specifically engineered to support English vocabulary acquisition for visually impaired students by integrating tactile, visual, and auditory experiences. The design process originated from a comprehensive needs analysis involving both students and teachers, which was subsequently translated into technical blueprints using SolidWorks 2023 software. The primary objective of this design phase was to ensure that every component of the media is accessible, safe, and ergonomic for visually impaired learners, thereby fostering a seamless, comfortable user experience.

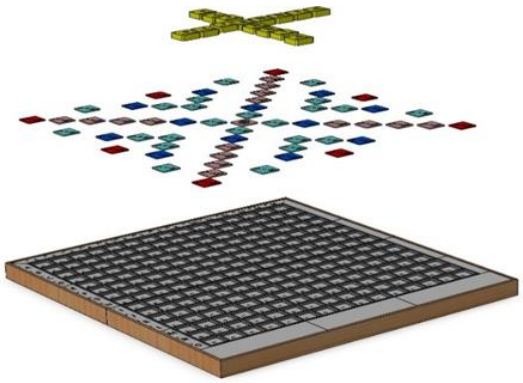

Figure 1. Initial Design of Braille Scrabble Media

The primary components of the media include the game board, letter tiles, a word list, and game instructions. The game board features raised grids and recessed holes in each square to keep the letter tiles stable during play. The letter tiles feature tactile Braille symbols on the surface and small pegs on the bottom to prevent shifting. The word list is produced in a dual format (Braille and printed text) and is integrated with barcodes that link to audio pronunciations and word meanings. Similarly, the game instructions are available in printed text, Braille, and audio formats, ensuring accessibility for all students.

The production phase utilized 3D printing technology for the board and letter tiles, while the word list and instructions were developed using a combination of conventional and

Braille printing. The game board is constructed from a combination of wood and acrylic, utilizing laser-cutting technology to create raised partitions that are easily identifiable through touch. The letter tiles are printed using durable plastic and painted to enhance legibility for sighted students. For the auditory features, each entry in the word list is equipped with a barcode that can be scanned with a smartphone, providing students with immediate access to audio files containing correct pronunciation and translations.

This design prioritizes not only accessibility but also aesthetics and ergonomic comfort. The use of high-contrast colors assists students with low vision, while the symmetrical layout of the board facilitates spatial orientation for students who are totally blind. By design, the media allows for simultaneous use by both visually impaired and sighted students, fostering an inclusive learning environment. This multifaceted approach is expected to significantly enhance social interaction, student motivation, and English vocabulary acquisition.

Figure 2. Main Design of Braille Scrabble Media

3.2. The Feasibility of Braille Scrabble Media

The feasibility of the Braille Scrabble media was evaluated through rigorous validation by media and material experts using a 4-point Likert scale. The material validation assessed the alignment with learning objectives, translation quality, spelling accuracy, and pronunciation clarity. The results in Table 2 show an exceptional total average score of 19.50 out of 20.00, achieving a 97.5% feasibility rate (Very Feasible). The experts emphasized that the vocabulary selection is highly relevant to the senior high school curriculum and effectively supports the English competence of visually impaired students.

Table 1. Material Validation Score Recapitulation

No.	Assessment Aspect	Validator 1	Validator 2	Total Average
1	Alignment with Learning Objectives	4.00	3.67	3.83
2	Translation Quality	4.00	3.67	3.83
3	Spelling & Writing Accuracy	4.00	3.67	3.83
4	Pronunciation Clarity	4.00	4.00	4.00
5	Presentation Order & Completeness	4.00	4.00	4.00
	Total feasibility (%)	100%	95%	97.5%

Simultaneously, the media validation focused on physical design, linguistic clarity, Braille readability, and usability. As shown in Table 1, the average total score reached 15.00 out of 16.00, resulting in a feasibility percentage of 93.75%. Experts specifically commended the media's durability and the ease of manipulating the letter tiles, placing it in the "Very Feasible" category.

Table 2. Media Validation Score Recapitulation

No.	Assessment Aspect	Validator 1	Validator 2	Total Average
1	Physical Design	4.00	3.60	3.80
2	Language & Instruction Clarity	3.60	3.20	3.40
3	Braille Display & Readability	4.00	3.60	3.80
4	Completeness & Ease of Use	4.00	4.00	4.00
	Total feasibility (%)	97.5%	90%	93.75%

In conclusion, both validations confirm that the Braille Scrabble media is highly suitable for classroom implementation. With only minor adjustments to the Braille tile layout required, the media is declared ready for limited field testing with visually impaired students.

3.3. The Practicality of Braille Scrabble Media

The practicality of the Braille Scrabble media was evaluated through response questionnaires involving English teachers and visually impaired students in two inclusive schools. Teachers provided an exceptional overall mean score of 3.95, emphasizing the media's seamless alignment with the national curriculum and the "School Life" thematic focus. The high scores across indicators such as instructional clarity, tactile recognition, and material durability demonstrate that the media is not only pedagogically sound but also robust enough for daily classroom use. This professional endorsement confirms that the multisensory integration—combining Braille and audio barcodes—simplifies the teaching process for educators while maintaining high accessibility standards.

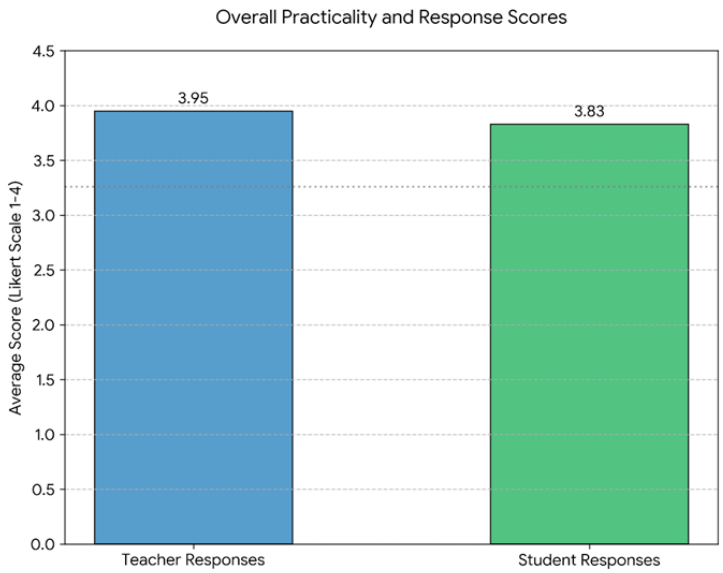

Figure 3. Graphic of The Practicality from Braille Scrabble Media

From the students' perspective, the media received a high practicality rating, with an average score of 3.83, placing it in the "Very Good" category. The students specifically highlighted that the media made vocabulary learning significantly more enjoyable and boosted their self-confidence when spelling English words. Perfect scores were achieved in the "Learning Enjoyment" and "Vocabulary Acquisition" categories, demonstrating that the game-based approach effectively reduces the boredom often associated with conventional audio-only methods. Overall, the consistent positive feedback from both teachers and students illustrates that the Braille Scrabble media is a highly practical, inclusive, and empowering tool that meets the diverse needs of learners in an inclusive education setting.

3.4. The Effectiveness of Braille Scrabble Media

The effectiveness of the Braille Scrabble media was evaluated through a pre-experimental design involving pretests and posttests. The assessment consisted of 10 multiple-choice questions covering word meaning, pronunciation, spelling, and contextual usage. As shown in the data below, there was a consistent and significant improvement in vocabulary mastery across all participants.

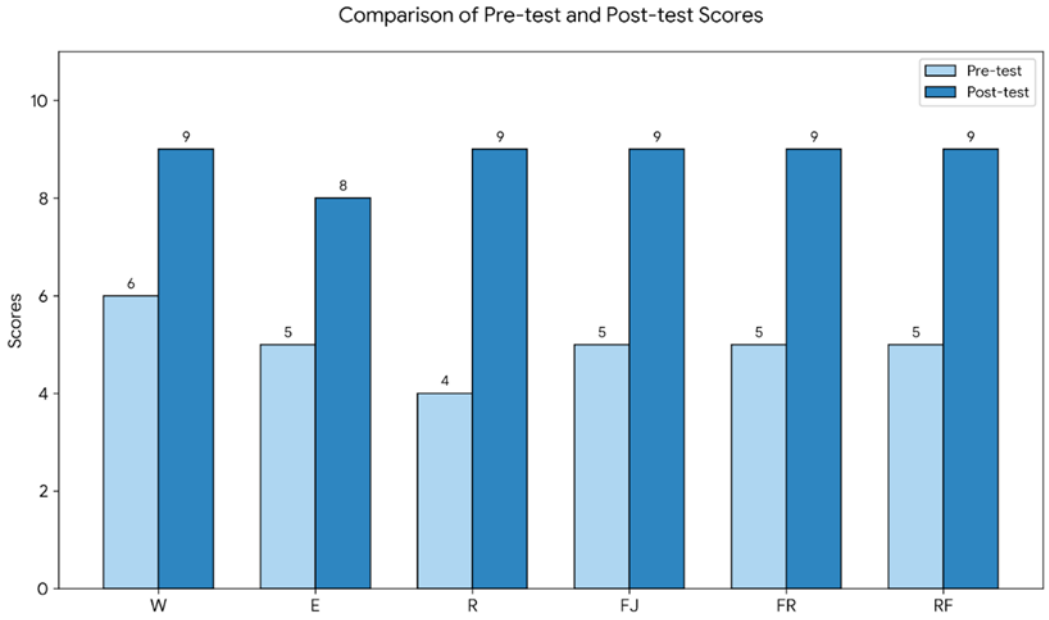

Figure 4. Graphic of The Media Effectiveness

The effectiveness of the Braille Scrabble media is empirically demonstrated by the significant increase in student scores across all participants. The quantitative data show that the average pretest score was 4.83, which rose substantially to 8.33 following the implementation of the media. This overall improvement of 3.50 points reflects a heightened mastery of English vocabulary, particularly in spelling, pronunciation, and contextual understanding. The consistency of this upward trend, as visualized in the chart, indicates that the media provides a reliable instructional framework for visually impaired students with varying initial competence levels.

The transition from pretest to posttest performance suggests that the multisensory features of the Braille Scrabble—integrating tactile Braille, visual text, and audio barcodes—successfully bridged the literacy gap. Students who initially struggled with word structures were able to construct and recognize vocabulary more accurately after engaging with the game-based media. This improvement is not merely cognitive but also reflects increased learning confidence, as students were able to independently verify their answers through audio feedback. Consequently, the media is proven to be an effective tool in enhancing linguistic outcomes within an inclusive secondary education setting.

4. DISCUSSION

The significant improvement in students' English vocabulary mastery, evidenced by a rise in average scores from 4.83 to 8.33, demonstrates that the Braille Scrabble media positively influences learning outcomes. This success is primarily attributed to the systematic development of the media, which aligns with the authentic needs of visually impaired learners identified during the analysis phase. By providing a structured yet engaging platform, the media effectively bridges the literacy gap caused by a previous over-reliance on audio-only technology.

The effectiveness of this media is theoretically grounded in the Dual Coding Theory, which posits that information is retained more effectively when delivered through both verbal and non-verbal channels. In Braille Scrabble, the verbal channel is facilitated through audio guidance via barcodes, while the non-verbal channel is realized through tactile Braille letters. This dual-processing approach ensures that students do not just hear the word but also understand its physical orthographic structure through touch.

Furthermore, the implementation of this media aligns with Multisensory Teaching theory, which emphasizes the integration of touch, sound, and active construction. By physically manipulating letter tiles to form words, students engage their motor and sensory systems, thereby significantly increasing information absorption and reducing the boredom typically associated with conventional methods. This active involvement aligns with the Nation's Vocabulary Theory, which holds that frequent, contextual interaction with words is essential for long-term retention.

Beyond linguistic gains, this media introduces a vital element of inclusivity and psychological empowerment that was missing in previous generic tools. The integration of printed letters alongside Braille allows visually impaired students to collaborate directly with their sighted peers, fostering a sense of equality in the classroom. Unlike earlier tactile-only versions, this multisensory innovation enables independent verification of answers through audio feedback, thereby reducing dependence on teachers and boosting student self-confidence.

5. CONCLUSION

The development of Braille Scrabble media has been shown to significantly enhance English vocabulary mastery among visually impaired students. The integration of tactile Braille, visual text, and interactive audio through barcodes creates a comprehensive learning environment that supports word recognition, spelling accuracy, and contextual

understanding. This success is rooted in a systematic development process that ensures the media is not only technically feasible and practical for classroom use but also highly effective in achieving pedagogical goals. During the analysis phase, the learning needs of visually impaired students were identified in depth. The design and development stages were grounded in the Dual Coding Theory [14], which posits that information is processed and retained more effectively when delivered through both verbal and non-verbal channels. In the Braille Scrabble media, the verbal channel is facilitated through audio guidance and word pronunciation, while the non-verbal channel is realized through tactile Braille letters.

The implications of this research suggest that multisensory-based game media are a vital tool for bridging the literacy gap in inclusive education. By involving touch, sight, and hearing simultaneously, this media reduces reliance on audio-only technology, which often fails to reinforce structural understanding of words. In practice, this innovation provides educators with an adaptive resource that fosters independent learning and psychological empowerment, enabling visually impaired students to compete on an equal footing with their sighted peers. This activity stimulates the students' sensory and motor engagement, supporting the argument by Greenberg & Cooper (2021) [15] that multisensory learning significantly increases engagement and information absorption for visually impaired students. Evaluation results further demonstrate that the media enhances vocabulary acquisition through active, contextual word-building activities. This aligns with Nation's (2013) [16] Vocabulary Theory, which emphasizes that effective vocabulary learning requires frequency, contextual meaning, and active involvement. Through the game-based approach, students can create and repeat words within a meaningful context, allowing vocabulary acquisition to occur naturally and enjoyably.

Despite its effectiveness, this study has several research boundaries. The implementation was conducted with a limited number of subjects, specifically six visually impaired students at SMK N 8 Surakarta and MAN 2 Sleman. Furthermore, the thematic focus was restricted to "School Life," and the media's durability was tested only within a short-term field trial. These factors limit the generalizability of the findings to broader vocabulary themes or different educational levels [17] - [19]. The barcode feature linked to audio pronunciation enables continuous multisensory learning, both in the classroom and independently. The practical, foldable design with integrated tile storage offers high accessibility and portability. This Braille Scrabble innovation introduces several novelties compared to previous research, including: (1) visual and tactile inclusivity through the combination of Braille and printed letters, (2) integrated interactive audio via barcodes, (3) dual-format instructional guides, and (4) a functional, portable design [20] – [25]. By applying Dual Coding, Multisensory, and Vocabulary Learning theories, this media serves as a concrete example of theory-based development implemented through design, content, and user experience.

For future research, it is recommended to expand the vocabulary modules to cover diverse topics and to involve a larger, more diverse group of participants to further validate the media's impact. There is also a significant opportunity to develop a digital or application-based version of Braille Scrabble that integrates more advanced assistive technologies. Such advancements would ensure that the media remains relevant and accessible in an

increasingly digital learning landscape. This research contributes to the general public by providing a concrete model for creating truly inclusive educational tools. It demonstrates how Universal Design for Learning (UDL) can be applied to foster social interaction and collaborative learning between students with and without disabilities. By promoting equality in the classroom, this study supports the broader goal of social inclusion, ensuring that visually impaired individuals have equitable access to language literacy and quality education.

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