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Research Article

Bridging Tradition and Innovation: Developing Contemporary Braille Piano Notations for Inclusive Piano Tuning Course

Wong Siew Ngan[1*], Chau Sau Hong[2], Lee Chie Tsang[3] and Lee See Ling[4]

[1]*Universiti Malaysia Sabah, Malaysia*

[2]*Segi College Subang Jaya, Malaysia*

[3]*Universiti Malaysia Sabah, Malaysia*

[4]*Universiti Malaysia Sabah, Malaysia*

Corresponding Author:
Wong Siew Ngan. Universiti Malaysia Sabah, Malaysia.

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Abstract

The development of the Joyful Braille Music Notation 2.0 is an expanded system designed to bridge the gap between traditional braille music notation and modern piano works for blind musicians. Building on the success of Joyful Braille Music Notation 1.0, which was tailored for choral music, the researchers aimed to adapt and extend this innovative system for piano music. Initially created to address challenges faced by blind students in a piano tuning course in Malaysia, the system has evolved through a user-centred design approach. The study involved experimenting with various notation formats to improve accessibility and ease of learning contemporary piano scores. The expanded Braille music notation system includes more than the traditional six-dot cell, enabling a more intuitive and efficient way to read piano music.

As a result, the Joyful Braille Music Notation 2.0 has been successfully incorporated into the curriculum for piano tuning courses for blind learners. This study highlights the impact of customised braille music notation systems in promoting greater inclusivity and accessibility in vocational education. The innovation also provides blind piano technicians with the tools to engage with and understand more complex technical repair and tuning of contemporary pianos. The Joyful Braille Music Notation 2.0 may also be evaluated for more advanced contemporary pieces for other musical instruments, further expanding its potential.

Keywords: Joyful Braille Music Notation, Blind Music Education, Extended Braille Piano Notation, User-Centered Design, Contemporary Braille Music Accessibility

Introduction

Braille music notation has been an essential communication system, allowing blind and visually impaired musicians to access, read, and perform musical scores independently. Developed in the 19th century and gradually standardised, the six-dot Braille cell continues to be the foundation for encoding musical symbols. Although this system has greatly enhanced music literacy for the blind, its complexity often presents challenges in reading efficiency, particularly with modern, multi-layered compositions such as contemporary piano pieces [1-3]. Traditional Braille music notation frequently requires many cells to represent a single musical idea, making it both space-consuming and cognitively demanding for learners [4].

To overcome these limitations, researchers and educators have sought to simplify Braille music representation while enhancing its expressive capacity. The Joyful Braille Music Notation (JBMN) system, first introduced by Wong and Chaw (2025a) for choral use, marked a notable advancement in tactile music reading [5]. JBMN redefines the tactile structure of Braille music by adding embossed lines around the six-dot cells to indicate musical functions that involve multiple symbols. This innovative approach allows musicians to interpret information such as phrasing, slurs, and dynamics through an expanded tactile field that more naturally mimics visual notation [6-8].

In conventional Braille music notation, slurs, ties, and phrases are represented using various symbols that often differ depending on the context and whether the application is for vocal or instrumental music. For example, conventional notation

distinguishes between single-syllabic slurs, double slurs, and phrasing indicators, which creates complex reading challenges for blind musicians. In contrast, JBMN simplifies these distinctions by using lines above the Braille cells to denote slurs, ties, and phrases. Longer lines represent longer phrases, while shorter lines indicate shorter slurs, aligning tactile reading more closely with musical flow [5,8,9]. This innovation significantly reduces the number of Braille cells required, enhancing reading fluency and comprehension.

Similarly, dynamics in traditional Braille notation rely on combinations of Braille cells and indicator symbols that must be memorised and recognised in sequence [6,10,11]. For visually impaired pianists, who often need to interpret simultaneous dynamic contrasts between left and right hands, this system can be especially challenging. The JBMN system addresses this by embedding embossed lines alongside the Braille cells: lines on the right indicate louder dynamics, while lines on the left represent softer dynamics. Multiple lines increase intensity in the respective direction, allowing tactile differentiation of dynamic gradations such as crescendo or diminuendo. This direct tactile correlation enables blind musicians to "feel" musical expression more intuitively, enhancing both interpretative accuracy and emotional connection to the music [5].

Building upon the foundation of the original JBMN, designed for choral music, the present study aims to extend the system to piano music [5]. This domain presents additional complexities due to its polyphonic nature and wide dynamic range. The adaptation process focused on maintaining tactile simplicity while accommodating multi-register notation, dynamic contrasts, and technical markings specific to piano repertoire. By simplifying the reading process and creating a more tactilely expressive notation system, Joyful Braille Music Notation 2.0 encourages greater artistic freedom and spontaneity in blind pianists [9]. When musicians no longer need to concentrate heavily on decoding complex Braille cells, they can redirect their attention to musical interpretation, phrasing, and expressive performance [10,12].

The tactile immediacy of the embossed lines allows performers to perceive musical contours, such as crescendos, decrescendos, and phrasing arcs, through touch, fostering a deeper physical and emotional engagement with the music. This not only speeds up learning but also nurtures creative decision-making, improvisational awareness, and dynamic shaping during performance. Consequently, JBMN 2.0 serves as a bridge between technical literacy and artistic expression, empowering blind pianists to explore contemporary repertoire with increased confidence and creativity.

Purpose of the Study

The purpose of this study is to document the development, implementation, and evaluation of the Joyful Braille Music Notation 2.0 system for piano music. Specifically, the research aims to examine how blind learners with different levels of visual impairment interpret and use this new notation in a practical learning environment. Using qualitative methods such as interviews, observations, and photo/video documentation, the study investigates the usability, tactile understanding, and overall preferences of blind learners regarding the JBMN system in comparison to traditional Braille music notation.

This research contributes to the expanding field of accessible music education, providing new insights into how personalised Braille notation systems can improve inclusivity, efficiency, and expressive understanding among blind musicians. The findings aim to support the adoption of JBMN 2.0 in music and vocational education programmes, particularly for blind learners pursuing professional skills in piano tuning and performance.

About the Joyful Braille Music Notation

In conventional braille music notation, all elements, including identifiers, slurs, phrasings, and notes in different registers, are represented using the six-dot cell (as shown in Figure 1).

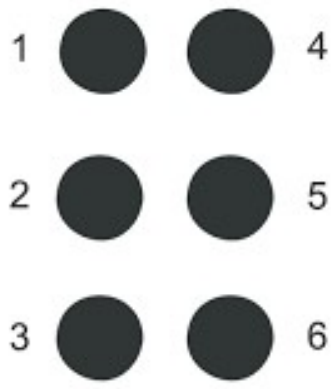


Figure 1: Braille Six-Dot Cell

General musical signs, including clefs, time signatures, key signatures, and other expression signs, are unlike the sighted music notations. Table 1 shows the differences in music notations for sighted and non-sighted musicians.

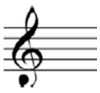
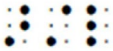
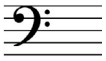
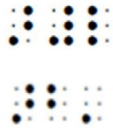
Clefs	Conventional Music Notation	Conventional Braille Music Notation
Treble clef		
Bass clef (for Bass) Bass Identifier (BANA, 2015)		

Table 1: Music Notations for Sighted and Non-Sighted Musicians

Treble and Bass Clef Reading in Joyful Braille Music Notation

The researcher further refined the Joyful Braille Music Notation (JBMN) system for piano by reducing the number of Braille cells used to signify clefs and octave registers. In standard Braille music notation, separate Braille cells are needed to denote the treble and bass clefs at the start of each line or section, which uses more space and complicates reading. To simplify this, the researcher adopted a fixed-doh system based on a consistent pitch reference [9].

In this system, the Braille cell for C (dot 1-4-5) signifies Middle C (C4) when used in the treble clef, and the same Braille cell indicates C3, one octave below Middle C, when used in the bass clef. This adaptation allows the notation to keep a fixed pitch reference while decreasing the need for repeated clef indicators. The difference between treble and bass registers is therefore suggested by the score's context and reinforced through the use of JBMN octave indicators, which are embossed lines placed above or below the Braille cells. Lines above the cells indicate higher octaves, while lines below indicate lower octaves.

By employing this method, the researcher effectively reduced the use of octave and clef indicators (for clef change on both right-hand and left-hand scoring), resulting in a more compact and efficient Braille score layout. This technique not only improves tactile readability but also lessens cognitive load for blind pianists, enabling smoother transitions between the treble and bass staves. Figure 2 demonstrates an example of this system, showing how JBMN replaces traditional clef markings with intuitive octave indicators that make reading and interpreting piano music easier [5,9].

Table 1 – Note Names, Solfège, and Values

Note Name/ Solfège	Quaver	Crotchet	Minim	Semibreve
C – Doh				
D – Re				
E – Mi				
F – Fa				
G – So				
A - La				
B – Si/Ti				
Rest				

Figure 2: Note Names, Solfège, and Note Values

The above note names, including their values, were adapted from conventional Braille notation, enabling the researcher further to eliminate the use of Braille cells in music scorings. The researchers also customised the universal braille music notation for time signatures and key signatures in JBMN. Figure 3 displays the quaver notes in Treble and Bass clefs for piano music [9].

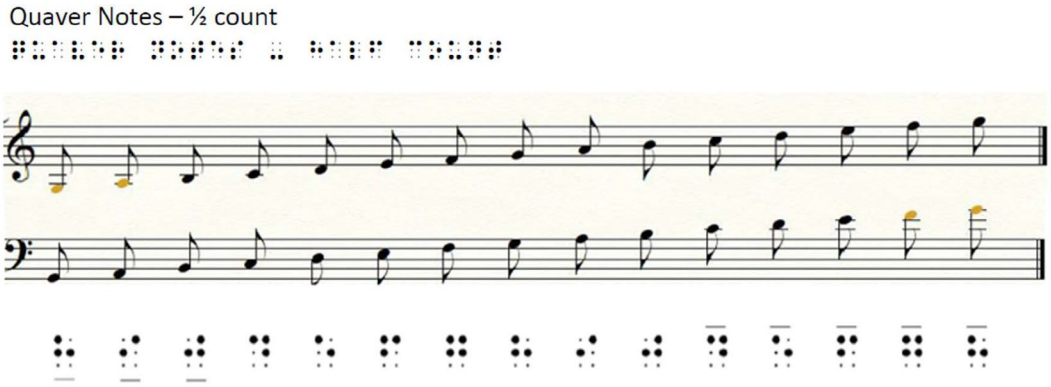


Figure 3: Quaver Notes for Treble and Bass Clefs

The Use of Lines Above and Below the Braille Cells

The researcher uses a single line above the braille cell to indicate notes an octave higher. More lines are used to indicate higher or lower octaves. For instance, two lines embossed above the Braille cell indicate notes two octaves higher, and vice versa. Conventional braille music notation employs different dots to indicate notes in various registers. Figure 4 shows the octave marks.

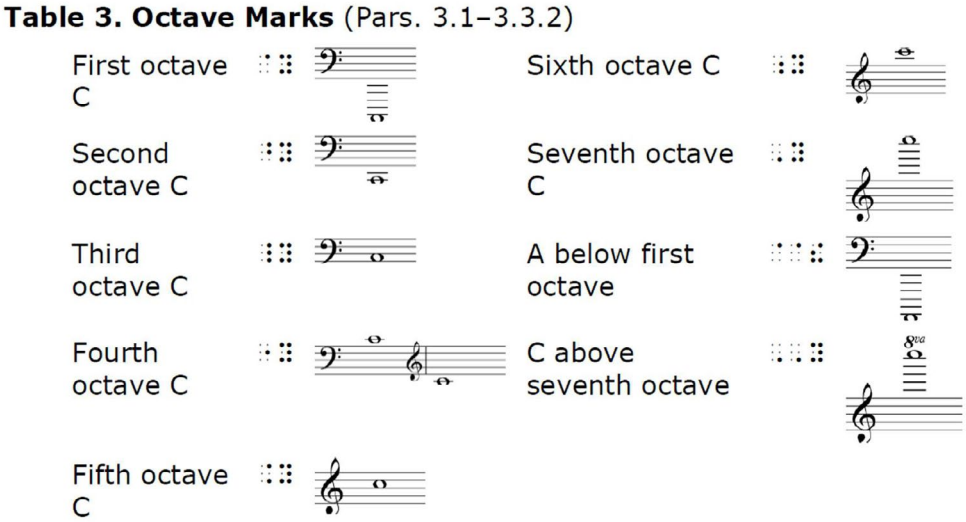


Figure 4: Octave Marks

The researcher could eliminate at least one braille cell for notes played in higher or lower registers by adding extended lines above and below the braille cells (as shown in Figure 3).

Slur, Tie, and Phrase Indicators

There are many types of slurs for vocal music in conventional braille music notation, including the single syllabic slur, doubled syllabic slur, phrasing slur, slur for variation of syllables between verses, and others. Figure 5 shows the indication for slurs using conventional braille music notation.

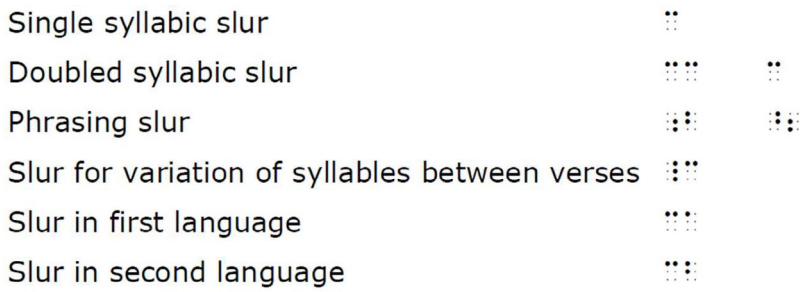


Figure 5: Braille music notation for different types of slurs (Adapted from BANA, 2015, p.33)

In Joyful Braille Music Notation, a line above the braille cells denotes slurs and ties. Figure 6 shows the Ties in JBMN [5].

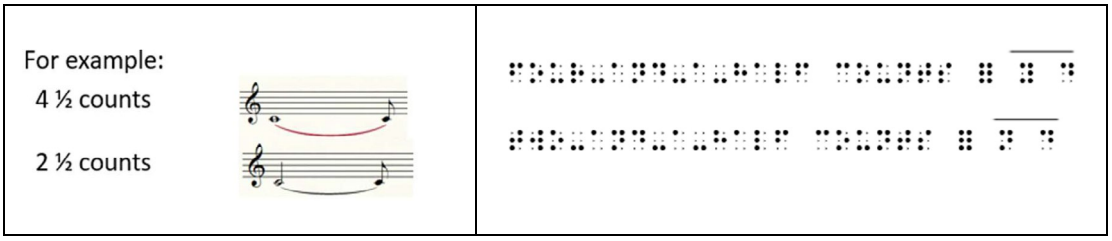


Figure 6: Ties in JBMN (Adapted from Wong & Chaw, 2025, p. 13)

Figure 7 shows the slurs in JBMN compared to conventional braille music notation.

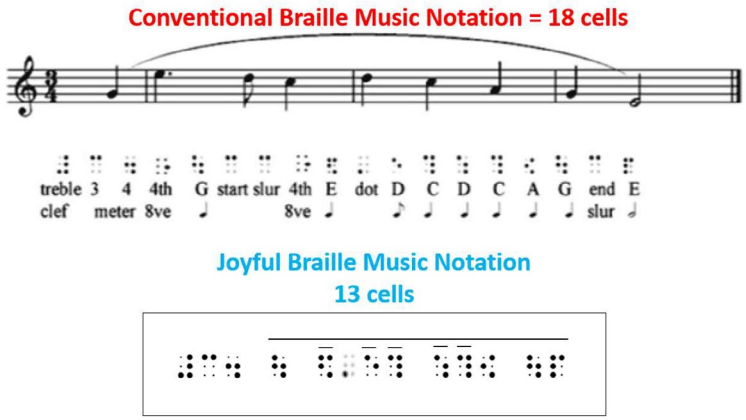


Figure 7: Slurs in JBMN Compared to Conventional Music Notation

This music passage uses fewer Braille cells with JBMN. The researchers enhance the innovation by adding lines above and below the braille cells for different register markings, longer lines for slurs, ties, and phrases, and lines beside the braille cells for standard dynamic markings. In the next section, the researcher will describe the use of lines beside the braille cells and how JBMN utilises fewer braille cells for dynamics [5,9].

Common Dynamics

The commonly applied dynamic range is usually between pianissimo (pp) and fortissimo (ff) [6,10,11]. Figure 8 shows the conventional Braille music notation for dynamics.

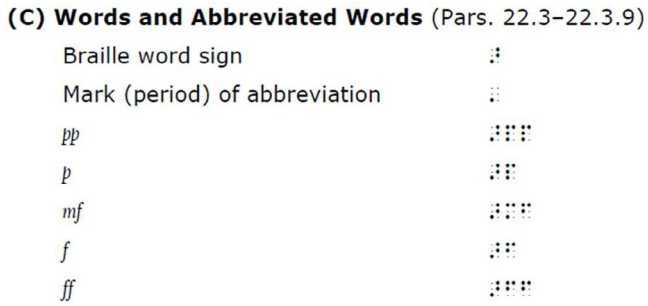


Figure 8: Common dynamic markings in conventional braille music notation. (Adapted from BANA, 2015, p. 33)

In the Joyful Braille Music Notation system, musical dynamics are expressed through the innovative addition of lines following the Braille music cells. A line to the right of a note indicates a louder dynamic, while a line to the left signifies a softer dynamic. These lines act as intuitive visual-tactile cues for blind musicians, allowing them to feel volume variations directly through touch. Once a dynamic mark is set, it remains in effect for all subsequent notes until a new mark is introduced, simplifying the reading process and ensuring continuity [5,9].

This method represents a significant advancement in braille music notation, particularly in capturing subtle dynamic variations. To indicate gradually louder or softer sounds, extra lines are included on the appropriate side of the note, multiple lines on the right for increased loudness and various lines on the left for enhanced softness. This multi-layered approach boosts expressive potential and provides blind musicians with a more precise, more direct grasp of dynamic transitions in a composition, filling a significant void in conventional Braille music understanding. Figure 9 shows the use of lines for different dynamics.

Table 7 – To the Right (Louder Dynamics)

Number of Lines	Dynamic Marking	Meaning
One line	mf	Medium loud (mezzo-forte)
Two lines	f	Loud (forte)
Three lines	ff	Very Loud (fortissimo)

Table 8 – To the left (Softer Dynamics)

Number of Lines	Dynamic Marking	Meaning
One line	mp	Medium soft (mezzo-piano)
Two lines	p	Soft (Piano)
Three lines	pp	Very Soft (Pianissimo)

Figure 9: The use of lines for different dynamics (Adapted from Wong & Chaw, 2025, p. 13)

Methodology

This study adopted a qualitative research design employing a User-Centered approach to explore and refine the Joyful Braille Music Notation 2.0 (JBMN 2.0) for piano music. The focus was on understanding the experiences, perceptions, and learning progress of blind participants as they interacted with the extended Braille notation system. The qualitative design enabled in-depth exploration of usability, accessibility, and learning outcomes through rich descriptive data gathered from direct observation, interviews, and multimedia documentation. The researcher is the facilitator in this study.

Samples

Six participants were selected from a piano tuning course for blind learners in Malaysia. The participants represented a range of visual impairments to ensure inclusivity and to examine how different vision levels influenced tactile reading and learning experiences. The distribution of participants was as follows:

- Grade 1 (Total Blindness): 3 participants
- Grade 2 (Severe Low Vision): 2 participants
- Grade 3 (Moderate Low Vision): 1 participant

Only one participant had prior experience with traditional Braille music notation. Five participants had prior piano playing and learning experience, with mainly auditory learning (learn by listening). One participant had no experience in piano playing and learning experience. Informed consent was obtained, and participants were briefed on the purpose of the study and the use of video and photographic documentation during sessions.

Research Duration and Procedure

The study was conducted over a period of 10 weeks, divided into three key stages:

Orientation and Needs Identification (Weeks 1–2): During this phase, the researchers carried out informal interviews and observations to recognise challenges faced by blind piano tuning students when interpreting piano scores with traditional Braille notation. Participants were introduced to the concept of the JBMN 2.0, emphasising the new tactile features such as embossed lines for octaves and dynamic indicators.

Learning and Skill Development (Weeks 3–8): Participants engaged in guided learning sessions to become familiar with the new notation system. They practised reading and embossing JBMN symbols/lines on specialised Braille paper using the new tactile indicators.

- Embossed lines above the Braille cells representing higher octaves (more lines indicate higher octaves).
- Embossed lines below the cells represent lower octaves.
- Embossed lines on the left and right of the Braille cells representing dynamic levels (lines on the left indicate softer dynamics; the more lines, the softer. Lines on the right indicate louder dynamics; the more lines, the louder).

Observations and photo/video recordings documented participants' hand movements, reading patterns, and tactile recognition. Most participants took about two weeks to become proficient in accurately embossing the new lines above, below,

and beside the Braille cells.

Evaluation and Reflection (Weeks 9–10): Semi-structured interviews and reflective discussions were conducted to gather participants' feedback on readability, tactile comfort, and overall usability. Participants were also observed while reading short piano excerpts notated in JBMN 2.0 and in traditional Braille music notation for comparison.

Data Collection Methods

Data were collected through three primary qualitative methods:

- **Observation:** The researcher documented participants' tactile reading behaviour, speed, and accuracy while learning the new notation system.
- **Interviews:** Semi-structured interviews were used to gather personal reflections on learning experiences, perceived benefits, and challenges.
- **Photo and Video Recording:** These recordings provided visual evidence of participants' engagement and allowed for detailed post-session analysis of hand coordination and tactile interpretation techniques.

Data Analysis

All qualitative data, including interview transcripts, observation notes, and visual documentation, were analysed thematically. Patterns were identified related to participants' learning and embossing progress, tactile understanding, and preferences in reading the new Braille system. Recurring themes were compared across participants to ensure consistency and validity.

Findings

All six participants were able to read and learn the Joyful Braille Music Notation 2.0 effectively within the ten-week study. The learning sessions were organised to gradually introduce the notational elements, starting with recognising the embossed lines above, below, and beside the Braille cells, and then moving on to reading short piano excerpts that included these tactile features. Participants showed consistent progress each week, advancing from basic recognition to fluent reading of complete piano passages notated in JBMN 2.0.

By the end of the tenth week, every participant could accurately identify pitch, octave placement, and dynamic direction solely through touch. This demonstrated that the tactile cues provided by JBMN 2.0 were comprehensible and adaptable, even for individuals who had spent years relying on traditional Braille music notation. The inclusion of octave and dynamic indicators through embossed lines proved particularly effective in reducing confusion during reading, especially in passages that involved frequent register changes or dynamic contrasts between the treble and bass regions.

Participants also expressed a sense of accomplishment in mastering the new system. During post-session interviews, several learners shared that JBMN 2.0 made music reading feel "more natural" and "less crowded," allowing them to focus more on the structure and musicality of the piece rather than the mechanics of decoding complex Braille patterns. All participants were excited to read the JBMN 2.0, which includes lines beyond the conventional six-dot Braille cells.

One of the central innovations of JBMN 2.0 lies in the use of embossed lines to indicate octaves and dynamics. Throughout the study, participants reported no difficulty in distinguishing or interpreting these tactile lines, whether they appeared above, below, or beside the Braille cells. The embossed lines were found to be easily perceptible by touch without obstructing the main Braille notation. In particular, the octave lines above and below the Braille cells were quickly recognised as intuitive tactile markers for pitch register. The participants discovered that the longer and shorter lines effectively distinguished higher and lower octaves, while the lateral (left and right) lines efficiently represented changes in dynamics. These spatial relationships, vertical for pitch and horizontal for dynamics, enabled participants to conceptualise the music in a way that closely resembled the visual experience of sighted musicians.

Moreover, the participants commented that the embossed lines felt consistent and comfortable under the fingers, providing clear and immediate reference points during reading. This clarity helped them maintain reading flow and reduce errors caused by losing track of position between notes and phrases. Such tactile coherence represents a significant improvement over conventional Braille music notation, which often requires additional symbols and spacing that interrupt reading continuity [13-15].

Although the reading process of JBMN 2.0 was quickly adopted, the embossing process, which involves manually creating tactile lines, took longer to master. Participants needed about two weeks to develop sufficient skill and accuracy in embossing the lines above, below, and on both sides of the Braille cells [16,17]. This period was marked by trial, error, and gradual improvement in tactile coordination.

The researcher introduced specific embossing tools for this purpose, including watch openers, which proved particularly suitable for creating both short and long tactile lines. Shorter lines were used for octave indicators, while longer lines represented dynamic markings [1]. Although these tools were new to all participants, they adapted to them with increasing confidence. However, participants, especially those with Grade 1 visual impairment (total blindness), initially struggled to maintain consistent alignment when embossing. The lines occasionally appeared misaligned, either too close, too far, or slightly slanted relative to the Braille cells. Despite these challenges, participants expressed determination and optimism, noting that with further practice they could improve the precision of their embossing. They also emphasised that the tools themselves were well-suited to the task and comfortable to handle once the correct technique was learned [4].

This process of tactile craftsmanship added a vital dimension to the study. It showed that the JBMN 2.0 system not only offers a new way to read music but also encourages fine-motor development and tactile awareness among blind learners. As participants became more adept at embossing, they also gained a stronger sense of ownership over their scores, personalising the notation according to their touch preferences.

All participants showed a strong preference for JBMN 2.0 over the traditional Braille music notation. This preference was based

on the more straightforward layout and fewer Braille cells needed to convey musical information. Participants noted that JBMN 2.0 scores appeared less cluttered, were quicker to read, and easier to remember. They also valued how the system combined multiple musical elements, such as pitch, dynamics, and phrasing, into a single tactile framework. Instead of memorising numerous Braille symbols and their combinations, learners could interpret the tactile lines and cells more intuitively [2,19]. The result was a smoother reading experience that improved both understanding and musical expression. All participants noted that this new system encouraged them to focus more on performance rather than decoding notation. They could "feel" the musical flow directly through touch, making the process of learning and performing more expressive and enjoyable. This preference aligns with the system's broader educational goals of improving accessibility, efficiency, and creativity for blind musicians [20].

Although the results were largely positive, participants' reflections also pointed out areas that need ongoing attention. The main challenge was the precision of embossing manually (by hand). While the tactile reading was clear, the manual embossing process required regular practice to ensure accuracy and consistency [21,22]. Participants agreed that creating evenly spaced lines, especially when embossing multiple layers (such as dynamics and octave indicators simultaneously), was a delicate task. Nonetheless, participants expressed confidence that these challenges could be overcome with experience. They also noted that the embossing tools introduced in this study were suitable and effective, suggesting that with minor ergonomic adjustments, they could become standard tools for blind musicians and educators working with JBMN [23].

Overall, the results demonstrate that Joyful Braille Music Notation 2.0 has effectively expanded the expressive and educational possibilities of Braille music for piano. This innovation allows blind students not only to read more easily but also to engage with the tactile and creative elements of music-making [24]. The findings confirm that, with ongoing refinement and practice, JBMN 2.0 can become a transformative tool in accessible piano education and performance.

Discussion

The results of this study demonstrate that Joyful Braille Music Notation 2.0 (JBMN 2.0) effectively supports blind learners in acquiring both musical and technical literacy within the piano tuning curriculum. Through qualitative evidence gathered from interviews, observations, and video documentation, this research reveals that JBMN 2.0 not only enhances reading fluency but also strengthens creative interpretation, tactile precision, and vocational confidence among visually impaired piano students [25].

Traditional Braille music notation, while systematic, often presents significant barriers for blind musicians and piano technicians [2]. The dense cell combinations and numerous octave indicators slow reading speed and increase cognitive demand. For piano tuning students, who must constantly connect sound, touch, and mechanical structure, this can interfere with developing a holistic understanding of piano acoustics and repertoire [26,27].

JBMN 2.0 mitigates these challenges by simplifying notation through tactile lines that mark octaves and dynamics. The system assigns C_4 (middle C on the piano) for treble passages and C_3 for bass clef readings, reducing the need for multiple octave symbols. Participants in this study were able to read and interpret piano excerpts more efficiently within ten weeks. This improved fluency enables blind piano tuners to study repertoire more thoroughly, internalize harmonic structures, and relate musical content to tuning practices such as string stretching, voicing, and regulation [6,11]. By allowing learners to "feel" melodic contour and dynamic shape through embossed lines, JBMN 2.0 transforms abstract pitch notation into a tangible acoustic map [28]. This tactile immediacy strengthens pitch memory, spatial perception, and skills essential for accurate aural tuning.

A central outcome of this project was the development of tactile craftsmanship among participants. Each learner engaged in embossing their own JBMN 2.0 materials using simple watch-opener tools. Although initial alignment errors occurred, particularly for Grade 1 participants, proficiency improved after two weeks of practice. This manual process paralleled the fine-motor coordination required in piano tuning, where subtle tactile sensitivity is needed to adjust pins, feel hammer motion, and gauge string tension [29].

Consequently, the act of embossing became both an educational and a practical skill. It promoted patience, accuracy, and sensory sensitivity, the very qualities that characterise skilled piano technicians [30]. Additionally, by creating their own tactile scores, learners gained autonomy and a sense of ownership over their educational resources. This self-authorship aligns with the principles of inclusive vocational education, where learners are empowered as active participants rather than passive recipients of knowledge [31]. While manual embossing fostered tactile awareness, the study also recognised the value of incorporating affordable embossing technology to enhance production quality and scalability. Low-cost mechanical embossers, portable line-embossing tools, or 3D-printed tactile devices can reproduce JBMN 2.0 lines with consistent thickness and spacing, ensuring uniform readability. For vocational institutions in Malaysia and similar contexts, such technology provides a cost-effective alternative to commercial Braille printers. Locally fabricated embossers can be assembled using accessible components, supporting the sustainability goals of inclusive education. Facilitators could quickly prepare standardised JBMN 2.0 scores for group lessons, allowing students to focus on interpreting rather than producing notation during classes.

Technological adoption also complements the hands-on learning of piano tuning. When combined with digital conversion software capable of translating MusicXML or MIDI files into JBMN 2.0 format, students can access a growing library of tactile piano excerpts. This integration of traditional craft and assistive technology demonstrates how innovation can democratize access to musical materials while respecting the artisanal roots of piano work [2].

Beyond technical literacy, JBMN 2.0 encourages creative musicianship and expressive performance. Participants reported that the tactile lines representing dynamic intensity and octave shifts allowed them to "hear" and "feel" musical motion more

vividly. The embossed textures guide the reader's imagination: ascending lines suggest tonal rise; denser right-hand lines evoke increased loudness; left-hand lines imply softness or withdrawal. This tactile-kinesthetic mapping stimulates interpretive thinking and expressive nuance, essential for both performers and tuners. Blind piano technicians, for example, rely heavily on auditory imagination to assess tonal balance [27,32]. By studying JBMN 2.0 scores, they can mentally anticipate harmonic progression, dynamic contrast, and phrasing, skills that translate directly into fine adjustments during tuning and voicing.

Furthermore, the streamlined design of JBMN 2.0 frees mental space for creative exploration. Learners can improvise or compose short motifs, experiment with phrasing, and connect musical emotion with mechanical sound production. The ability to interpret tactile cues instinctively boosts confidence in both artistic and technical areas, bridging the traditional gap between performer and craftsman [33]. This harmony of creativity and technical precision fosters a more holistic approach to piano teaching for the blind. Music reading, instrument care, and artistic expression become interconnected skills rather than isolated disciplines. In this way, JBMN 2.0 functions not only as a notation system but also as a framework for creative vocational learning.

From a pedagogical standpoint, integrating JBMN 2.0 into piano tuning courses offers a model for inclusive curriculum design based on Universal Design for Learning (UDL) principles. This innovation provides various modes of engagement – tactile, auditory, and kinesthetic, catering to learners with different levels of visual impairment. Facilitators can use JBMN 2.0 scores to teach pitch relationships, harmonic analysis, and sound regulation techniques simultaneously. For example, while reading a tactile passage marked with dynamic lines, a student can tune corresponding piano strings and immediately perceive how tonal intensity aligns with embossed textures. This multisensory approach turns abstract theory into practical experience, improving memory retention and conceptual understanding. Moreover, the participatory nature of embossing and reading encourages collaboration among students. Group activities, such as comparing embossed patterns or co-creating tactile exercises, promote peer learning and social inclusion, essential for fostering community among visually impaired learners [34].

The findings suggest that the evolution of JBMN 2.0 marks an important step toward an inclusive, creative, and technologically enhanced future in music and vocational education. Its design encourages continuous interaction between tactile exploration, auditory imagination, and manual skill – all central to the identity of blind piano technicians and musicians. With the introduction of low-cost embossing machines, educational institutions can implement JBMN 2.0 widely without financial strain. When combined with ongoing research in digital conversion and 3D tactile design, this system could evolve into a comprehensive platform supporting multiple instruments and ensemble performance [2].

Most importantly, JBMN 2.0 demonstrates that accessibility and artistry are complementary. By simplifying notation, integrating affordable technology, and connecting tactile design to creative performance, this system changes how blind learners think, feel, and work with music. JBMN 2.0 enables them not only to read and tune pianos more effectively but also to express themselves artistically, capturing the essence of music as both craft and inspiration.

Conclusion

The development and implementation of Joyful Braille Music Notation 2.0 represent a transformative advancement in inclusive music and vocational education for blind learners. This study demonstrated that blind piano tuning students were able to learn and apply the JBMN 2.0 system effectively within ten weeks, mastering both reading and embossing skills while enhancing their musical understanding and technical awareness. The findings affirm that this tactilely intuitive system not only simplifies the process of reading piano scores but also enriches the creative and cognitive dimensions of piano tuning education [35].

JBMN 2.0's design, featuring tactile lines above, below, and beside Braille cells to represent octave and dynamic variations, enables learners to experience music through touch more directly and expressively. This tactile innovation provides a sensory bridge between musical notation and the physical sound world of the piano. As blind technicians must rely heavily on auditory and tactile feedback in their tuning work, the integration of JBMN 2.0 strengthens their aural precision, pitch memory, and tonal imagination. This innovation allows learners to connect what they feel in notation with what they heart on the instrument, forming a holistic foundation for both artistic and technical growth [36].

The research also revealed that the process of manual embossing developed fine motor skills, patience, and self-discipline – attributes essential to professional piano technicians. Although the embossing process initially posed challenges, participants reported a sense of achievement and empowerment as they gained better control and accuracy. The use of simple tools, such as the watch openers, demonstrated that accessibility can come from creative adaptation rather than expensive equipment. This finding underscores the importance of encouraging practical ingenuity and independence among blind learners.

Moving forward, the study recommends adopting low-cost embossing technologies, such as mechanical or 3D-printed embossers, to enhance the scalability and consistency of JBMN 2.0 for institutional use. Affordable tactile printing devices can improve alignment, reproducibility, and increase access for schools and community programmes across Malaysia and beyond. Additionally, developing digital translation software to convert standard music files into JBMN 2.0 format could further democratise access, allowing educators and learners to create Braille music resources easily [7].

The integration of JBMN 2.0 into piano tuning courses has shown that inclusive design can empower blind students to become not only competent technicians but also expressive musicians. The system nurtures creativity, enhances interpretive performance, and bridges the gap between technical skill and artistic identity. In doing so, it challenges conventional boundaries between vocational and creative training, offering a more holistic model of learning rooted in touch, sound, and imagination [37].

Ultimately, Joyful Braille Music Notation 2.0 is more than just a new notation system; it is a pathway to creative independence and professional dignity for blind musicians. By combining tactile innovation, accessible technology, and human-centered pedagogy, it redefines what it means to "read" and "feel" music. As this system continues to develop and expand to other instruments and educational contexts, it holds great promise for fostering a more inclusive, expressive, and joyful future. [38-46].

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