**Writing Braille:   
Two Centuries of Tools and   
Techniques, and How We Can   
Strengthen Them for the Future**

Presentation

By Jennifer Dunnam

National Federation of the Blind

# Abstract

The shorthand designation "braille readers" to reference individuals who use braille for communication can serve to convey an incomplete idea of the role of braille—i.e., that braille is generally a medium to be made available *for* a blind person to peruse. While a focus on reading and on the preparation of materials for doing so is, of course, vitally important, the active use of braille *by* individuals for record-keeping and external communication brings its own set of issues that need attention in education and other spheres— particularly in our age of digital communication. To view braille writing through its own distinct lens can help us understand and address today's braille writing possibilities and barriers.

This paper provides an overview of how the tools, functionality, and communication reach of braille writing by blind individuals have evolved over the past two centuries. It explores current challenges and questions around digital braille writing, including differences in braille-centric vs. print-centric digital braille writing environments, discrepancies in electronic translation from braille to print, individual access to braille embossing equipment, and more. It offers suggestions on focus areas for the future.

# Introduction

What does it mean to "write braille"? That question may once have been answered quite simply—"to write using six keys (plus a space, backspace and return key) or a slate and stylus, so that the writing can be read back by touch in braille dots." As methods of writing in general have changed, ideas of what constitutes writing braille are also expanded. But what are the boundaries? It still seems almost miraculous that now, someone who knows nothing about braille can send a communication to be read instantaneously by someone who reads braille. A braille user with a mobile device can capture an image of written notes—even handwritten notes—and have it processed and presented in braille. Nevertheless, the digital reproduction of an image and the communication from a non-braille user fall outside of what will be discussed here. Instead, we will focus on writing that is generated from a person who needs nonvisual techniques to access the writing.

As we will explore, electronic communications make the method of "writing" less tied to the format of its result, and there are reasons to focus separately on each of these aspects. For this discussion, two types of writing by an individual fit: 1) writing that is done with braille keys, a slate and stylus, or a virtual braille keyboard; *or* 2) writing that results in braille that can be read by touch.

From the perspective of the user experience, the tools used for writing braille differ in their portability, cost, maximum achievable writing speed, size of braille display, labeling capability, ease of editing, ability to make the result match the intent, ability to assess whether the result conforms to the intent, ease of communicating with non-braille-readers, and other criteria. Beginning with the frame that Louis Braille created by modifying Charles Barbier's writing board (Mellor, 2006), through the interconnected refreshable braille device used for communication with anyone and everyone, the tools for writing braille have both persisted and evolved. Each innovation has brought with it certain advantages, but none by itself has provided all of the equivalents needed to replace functions of the older tools. Thus, the manual, the mechanical, and the digital all co-exist as essentials in a braille user's toolbox. As the electronic braille writing devices continue to advance, so must our understanding of both their power and their limitations.

# Braille Writing Tools

## The slate and stylus

As old as braille itself, this traditional method for writing braille by hand remains the most portable and economical of all the tools. With no electronics or batteries to fail, and no intervening translation software, the slate and stylus is a basic, direct medium between the human brain and the page. The dots punched by the person are the dots that appear on the paper—perfection and mistakes alike.

Perceptions of the right-to-left writing as "backward" are generally more of a deterrent to use of the slate than any inherent drawback of the slate itself. Fluent slate users can write at speeds equivalent to that of a pen or pencil, and the use of an abbreviated code like grade 3 braille can enhance speed even more. Many used the slate for extensive notetaking or even to work mathematics—some still do so today in regions where the slate is still prominent. Cardstock paper makes for writing that is more durable; thinner paper can be used to make writing easier and quieter. The slate must be removed from the lines it covers during writing in order to read those lines, but, aside from that, the size of the page determines how many lines of braille are accessible to be read back at any one time.

Early slates included a board to which the paper was attached, with holes in the sides to move the frame down for each new set of lines. Slates with pins directly on the frame for stabilizing the paper provided an even more portable option and became the standard in many places. Although a four-line slate that fits across the width of a page can be used with other paper sizes, slates have been manufactured in a wide variety of sizes and configurations to meet the needs (Dixon, 2019). Capable of creating braille labels for physical objects or of being tucked in with an advanced electronic device for backup in case of emergency, the slate and stylus remain unmatched in versatility for personal braille writing.

For much of its history, the only way to extend the reach of communication written on a slate beyond other braille readers involved reading the writing aloud to be copied by a sighted scribe. The blind writer could also make a copy of the writing using a typewriter. Neither of these methods allow the writer to confirm directly that a faithful copy has been made.

## The Mechanical Brailler

The advent of machines for writing braille at the turn of the twentieth century, and their significant refinement in 1951 (Tobe, 2001), brought about options for writing and editing braille with greater efficiency. The writing is done from left to right on the front of the paper, which can be less off-putting to some than is the slate method. Writing can be done as rapidly as on a typewriter, and the writing can be read immediately after it is written, without the need to remove the paper from the device. Editing can be accomplished quickly by rolling the paper to the desired line and moving the carriage to the desired cell. As with the slate and stylus, deletions are made by erasing dots with a fingernail or braille eraser, or by writing full braille cells over the area to be deleted. The ease of moving the paper brings increased efficiency to the working of mathematics, or to the writing of spatial material.

As with the slate, the dots from a mechanical Brailler appear exactly as typed by the writer, and the size of the page defines the display area. Less portable and at higher price than the slate and stylus, the mechanical braillewriter's rugged construction and easy operation have nevertheless kept it in wide use today.

Copying the writing on a print typewriter or dictating it to a human scribe remained for decades the primary ways to share the written work with those who do not read braille. In mainstream educational settings, a teacher of blind students or paraprofessional who knows braille can hand write the student's work directly on the page for submission to the classroom teacher. Even with the electronic options of today, this method, known as interlining, provides the advantage of allowing the student to work in a braille-centric way, especially when writing mathematics or other spatial material.

In the mid 1980s, an accessory for the Perkins Brailler, called the Braille-n-Print, became an early effort to allow those writing braille on paper to share their work directly with non braille users (APH Museum). The standard Brailler was placed on top of a metal box with spring-loaded keys that activated with the press of the Brailler’s keys. When the user pressed the line advance key, the device translated into print the line just brailled, then printed the line on a connected daisy-wheel printer. The Braille-n-print had no way to synchronize with any edits made on the braille page, and there was no way for the writer to verify directly the accuracy of the translation and print-out. The noisy line-by-line printing also made the approach impractical in a classroom setting, but the effort helped to clarify some of the challenges to be addressed.

## Six "Keys", No Dots

The coming of the Braille’n Speak in 1987 sparked praise and controversy. The six-key device, with its internal storage, small size, and extra functions like a clock and calculator, offered portability closer to that of a slate and stylus along with braille writing speed more like that achievable on a mechanical braille writer (with less noise). Unless connected to a braille embosser, however—an option unavailable to many and inconvenient besides, its only nonvisually accessible output was a translation from braille to synthetic speech. It could also export the writing to a printer, but the writer had no nonvisual way to be certain that the translation was correct. Nevertheless, the device remained wildly popular for many years because of its functionality. In theory, it seemed ideal to help blind students in mainstream settings needing to communicate their work to their teachers and to take their own notes. Unfortunately, the Braille’n Speak and other similar devices were sometimes deployed in educational settings without a clear understanding that they did not address the “reading” half of the literacy equation for students.

Decades later, mainstream mobile devices, with quantum leaps forward in functionality, are now essential in the lives of many and can be accessed with a screen reader through speech and/or braille. For many braille users, the best nonvisual method of writing on a touch screen is through Braille Screen Input (BSI). BSI involves calibrating six fingers on the screen and then tapping them in the same configurations used with braille keys. Gestures are available for deleting by character and by word. The device can be oriented vertically, with the screen facing away from the writer, for writing while standing up. Writing on a touch screen can generally be accomplished much more quickly this way than through using the on-screen keyboard. Although no tactile dots are involved, BSI is an essential tool for writing on a mobile device when it is inconvenient or impossible to connect an external communication device, and its utility relies on accurate braille-to-print translation.

## Six Keys, Refreshable Braille

The BRAILLEX, the first refreshable braille device, was designed by Papenmeier Company in Germany and was released to the public in 1975. The BRAILLEX, and other similar early devices like the Versabraille, did not involve translation to or from print, but they stored and retrieved braille data using cassettes, with a limited editing capability. They displayed one line of braille at a time, via electromechanical cells with pins that raised and lowered in different combinations as information was typed or read. Although considered portable by the standards of the day, they were quite fragile and could not be used on the go.

Over time, refreshable braille devices became more affordable and portable, with internal file storage, and they began to include print translation and options for connectivity. Most refreshable braille devices now include synthesized speech output, which can be disabled as desired. A one-line display is still commonplace, although line lengths vary. A variety of navigation keys and shortcuts are typically available for faster movement through books or other documents.

Two distinct environments for writing braille are available in most stand-alone devices of today. In this discussion, we will refer to these as the **braille-centric** and the **print-centric** environments. Helpfully, some of the newer refreshable braille devices have implemented two separate document editors within their own suite of internal applications—one specifically designed for each of the two environments. If the writer knows that the document will be needed in a non-braille format, the appropriate editor can be used so that no export is necessary.

### Braille-centric Braille Writing

In a braille-centric environment, the writer interacts with a braille format file, and typing is done without translation of any kind. Similar to brailling on paper, as typing occurs, the display presents exactly the dot configurations that have been typed. If the document is for personal use, the writer can work math problems, underline words using braille typeform indicators, and make up symbols or shorthand if desired. Many devices have powerful editing capability in this format, allowing blocks of text to be moved or deleted. A search can be done on any dot configuration.

If a print-based version of the document is ultimately required, then, once the typing and editing are complete, it can be translated to print and exported to a print-based format for sharing with others. On some devices, the user can even copy the text to a clipboard and send it to an external device via Bluetooth.

### Print-centric Braille Writing

In the print-centric environment, the user also types with six keys, but the destination for the typing is either a print-based file format like .txt or .docx, or the interface with an application or the device itself. Typing into a search bar on a browser, a text message, and a Google Doc are all examples of the print-centric environment.

This environment is in effect by default in screen readers or devices interacting with print-based applications. As the writer types with six keys, two things happen in quick succession. First, the typed text is translated from braille to print and written to the destination. Then, to display for the user what has been written, the material is translated back to braille. If both the typing and the translation system are accurate, the dots displayed will generally be the same as the dots typed—in other words, the user experience is very similar in the print-centric and braille-centric environments. However, in the case of general typing errors or braille rule violations by the user, or of inaccuracy in the translation software, the braille displayed back will differ from what was typed.

If the user is writing in contracted braille but forgets to use a certain contraction in a word, then, after its round trip translation, the word will display with the contraction in place. If, on the other hand, the user employs a contraction in a manner that is against the rules, an accurately-functioning system will translate the typing to print according to the braille rules, then present a braille translation of the result. The user is immediately notified of the error and can make a correction. If inaccuracy exists in the translation software, the writer’s ability to discern and correct errors is hindered.

On some of the more feature-rich braille devices, structured mathematics can be written out accurately in this environment within internal applications. The user toggles into a mathematics mode via a specified keystroke to write out the expressions using the braille math code. The prepared document can then be exported to a format readable by a print user.

A six-key device connected to an external device is also operating in the print-centric environment. The connected braille display is driven by the screen reader on the external device, including whichever translation program is in effect in conjunction with that screen reader. The connection between the devices can impact the writing experience if there is lag or unexpected disconnection.

## QWERTY Keyboard with Refreshable Braille

Some writers of braille prefer a QWERTY interface on a braille device even when reading the result back in braille, because of the familiarity of dedicated key combinations for navigation and editing, and also because of experiences with unreliable braille-to-print translation. Some writers can use both types of keyboards with equal agility and use either at different times. Braille devices with built-in QWERTY keyboards are usually larger than the six-key devices. When the writer works on a QWERTY desktop or laptop computer with synthesized speech running, proofreading and editing are made more efficient by a connected braille display, with its handy cursor routing buttons, for quickly placing the cursor at a specific spot.

Since typing on a QWERTY keyboard is naturally print-centric, the real-time braille translation only goes one way—print to braille—for displaying back to the writer.

## Dictation and Braille

Although dictation using the human voice may stretch the definition of “writing”, today’s ability for an individual to jot down a note or compose a masterpiece using only a voice, then read back the information in braille, merits mention here. Braille is a highly reliable and efficient nonvisual way to catch and correct the inevitable and abundant errors that occur in dictation. Such errors often go undetected when listening to the results read aloud by a screen reader, making braille a crucial tool for nonvisual editing of dictated work. Editing a dictated passage may take just as much effort as having typed it in the first place, but dictating to braille is a viable option in cases where typing directly is not feasible—or in any case where a print user might just as likely dictate.

## The Braille Embosser

Many who write something onto a digital device still prefer ultimately to commit the writing to paper. For notes taken for later study, a to-do list, a presentation to be given before an audience, having access to the full page of writing, in a format that will not freeze up or become unavailable at the worst possible moment, can reduce stress and make the document easier to work with.

# Digital Braille Writing: Problems and Possibilities

Unified English Braille (UEB), which has been the standard for English speaking countries for many years, was carefully developed to ensure that both print-to-braille and braille-to-print electronic translation would be accurately supported. UEB has removed the ambiguities and conflicts that particularly frustrated reliable translation from braille to print. Programmers from commercial companies and with open-source projects like Liblouis have made enormous progress toward fully realizing the potential brought about with the adoption of UEB.

Yet, there remains room for improvement to bring about the level of reliability needed for those who write braille to use it confidently, and for learners to develop braille writing fluency in a digital environment.

## Print-To-Braille

As we have seen, print-to-braille translation plays an important role in allowing the writer to read back what has been brailled in a print-centric environment. Tremendous strides have been made in improving the print-to-braille accuracy of the most widely-used translation software. Primary remaining issues for improvement include display of typeforms such as italics, identifiable representation of certain symbols such as emoji, and mathematics. The difficulties pertain to the interaction of specific screen readers with the translators.

For example, the NVDA screen reader, using Liblouis, can display italics, bold, and underline using UEB typeform indicators when the settings are correct; JAWS, also using Liblouis, can delineate typeforms very well using speech, but it will not display the standard braille indicators. The VoiceOver screen reader can display the indicators only in limited circumstances.

## Braille-To-Print

More focus is needed on braille-to-print translation for UEB in software that has been widely deployed in screen readers. Mathematics and typeforms are at issue here as well. At a more basic level, some gaps exist particularly in Liblouis’s observation of braille rules on the path from braille to print. The first example below pertains to the rule about lower groupsigns in UEB §10.6.5. The second example demonstrates an opportunity for improvement around mode-related rules. These examples were created using Liblouis 3.28:

### Error Example 1:

**User Brailles to Liblouis:** ⠓⠞⠞⠏⠒⠬⠸⠌⠸⠌

**Liblouis translates to print:** httpcc//

**Liblouis displays in braille:** ⠓⠞⠞⠏⠉⠉⠸⠌⠸⠌

UEB §10.6.5 says, in pertinent part, that the contraction for **cc,** dots 25, is used when the letters it represents are preceded and followed by a letter, contraction, modified letter, or ligatured letter. For a braille-to-print purpose, this rule can be roughly restated as “if dots 25 is preceded and is followed by a letter, contraction, modified letter or ligatured letter, it represents the letters **cc.** If it is not preceded and followed by these, then it does not mean **cc.”** Additionally, §10.6.2 indicates that if dots 25 is at the beginning of a word and followed by a letter, contraction, modified or ligatured letter, it represents the letters **con,** and does not stand for these letters if the conditions are not met. If neither §10.6.5 nor §10.6.2 apply, as is the case in this example in which a slash follows the dots 25, then dots 25 represents a colon.

A related and larger problem is demonstrated by attempting to force the desired colon by inserting a grade 1 symbol indicator before the dots 25. This work-around should solve the issue but has no effect. Likewise, typing a colon at the beginning of a “word”, as may be done to invoke a “smiley-face”, does not work properly with or without the use of a grade 1 symbol indicator. To type a colon, the writer must resort to the QWERTY keyboard.

### Error Example 2:

**User Brailles to Liblouis:** ⠼⠋⠹ (user erroneously brailles a “th” contraction)

**Liblouis translates to print:** 6th

**Liblouis displays in braille:** ⠼⠋⠞⠓

UEB §6.5.1 indicates that the numeric indicator sets grade 1 mode, which is terminated only by a space, hyphen, dash, or grade 1 terminator. Thus, symbols between the numeric indicator and any of the afore-mentioned terminators are not to be read as contractions.

Upon being shown different dots from what was typed, the user might naturally assume, in our age of artificial intelligence and auto-correct, that the kindly, forgiving device knew what was intended and had offered a correction to the user error. The real story is that the user made a braille error, the software did not observe the numeric mode rule, and the result of the combined errors happened to match the user’s original intent.

The innocuous-seeming response from the translator in this example serves to conceal what is actually a significant problem that extends far beyond this single instance. The trouble can be demonstrated by brailling any number followed by a strong groupsign (like ⠼⠙⠊⠻ for 49er), or by other contractions with initial letter capitalized (like ⠼⠃⠠⠐⠙ for 2Day). The translator reads these as contractions, in violation of numeric mode, and displays the braille back in correct form (⠼⠙⠊⠰⠑⠗, ⠼⠃⠠⠙⠁⠽). The failure to apply numeric mode rules correctly on the path from braille to print creates ambiguities in general; further, it presents a roadblock to brailling mathematics in a print-centric environment.

For the record, the “System” translator in the VoiceOver screen reader, which handled example 1 correctly, handled the braille error in Example 2 like this:

**User Brailles to Liblouis:** ⠼⠋⠹

**Liblouis translates to print:** 6?

**Liblouis displays in braille:** ⠼⠋⠦

Although also not quite correct in that the dots 1456 should likely have been ignored, this response did observe the numeric mode rule, and the displayed braille alerts the user that the intended “6th” was not registered.

# Additional Areas for Consideration

1. In some but not all screen readers and devices running refreshable braille, if a user needs to type into a search bar or other form fields, the message "computer braille is required" is displayed. This informs the user that to type with six keys in these fields, the usual UEB symbols cannot be used. Rather, completely different dot combinations must be typed for numbers, capital letters, and nonalphabetic symbols like the period or colon. This required switch to computer code is a relic of the ambiguities in pre-UEB codes. Screen readers and devices should cease requiring a switch from UEB to computer code in these commonly-encountered instances, as it is a hindrance to braille writing, especially for those who never learned the older alternate symbols.

2. Writing with six keys on the “braille side” in the Duxbury program provides highly reliable braille-to-print translation, including use of typeform indicators and mathematical expressions. How can this user experience of writing digital braille be made more universal?

3. Opportunities are needed for teachers of blind students to better understand issues of digital braille writing, beyond commands for operating the devices, so that they can support their students in navigating the issues.

4. The BrailleBlaster translation program includes a method for transcribers to submit print-to-braille translation errors. A venue for braille users to call out braille to print errors and have them corrected would also be helpful.

5. Amid all the electronic communications, the ability for the blind individual to create braille for labeling remains important and must not be overlooked in education. Without easy access to and comfort with the use of tools like a slate and stylus or Perkins Brailler, a blind person loses the agency to create braille labels for their own cleaning solutions, credit cards, medications, baking supplies, microwaves, vinyl records, and on and on. Other labeling methods such as audio tags, OCR apps, and visual interpreters fill the gap; these are useful tools for first-time identification, but when an item is used again and again, quick identification by touch offers greater efficiency.

6. Access to multiple lines of braille at once on a braille display brings forth exciting possibilities, not only for tactile graphics and spatial materials, but for reading and writing in general. The great work on projects like the Canute 360, the Monarch, the Cadence and the rest are to be commended!

7. As always, tremendous kudos to the knowledgeable and dedicated people who continue to put much time and effort into making the open-source Liblouis package ever stronger, for English speakers and for all users around the world!

# Appendix:

# COMPARISON OF FUNCTIONALITY OF BRAILLE WRITING TOOLS

The following rankings are not intended to assert superiority of one braille writing tool over another. Rather, the purpose is to illustrate the evolution of functionalities with the advent of new tools, and to underscore the point that no single braille writing tool currently in existence is capable of fulfilling all of the possible needs.

The rankings assume fluency with all of the tools. A user’s braille fluency, comfort level with technology, experience level with a given tool, access to the latest software and hardware, and other factors will affect the individual’s experience.

## Key to Rankings

3 = None of the tools rank higher

2 = Some tools rank higher, some lower

1 = Where the criterion applies, no tools rank lower

0 = The criterion is not present in this tool

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| --- | --- | --- | --- | --- | --- | --- | --- |
| Criterion | Slate And Stylus | Mechanical Brailler | Computer with Embosser | Smartphone With Braille Screen Input | Notetaker, Speech Output | Notetaker, Refreshable Braille | Screen Reader Driving Braille Display |
| Portability | 3 | 1 | 0 | 3 | 3 | 2 | 2 |
| Cost | 3 | 2 | 1 | 2 | 2 | 1 | 1 |
| Max. Achievable Writing Speed | 1 | 3 | 2 | 2 | 3 | 3 | 3 |
| Surface Area Of Braille Accessible At Once | 2 | 3 | 3 | 0 | 0 | 1 | 1 |
| Ease of Editing | 1 | 2 | 2 | 2 | 2 | 3 | 3 |
| Ease of Communication with Non-Braille-Readers | 1 | 1 | 2 | 3 | 2 | 3 | 3 |
| Ease of Process, Beginning To End | 2 | 3 | 1 | 2 | 3 | 3 | 3 |
| Can Label Physical Objects | 3 | 3 | 2 | 0 | 0 | 0 | 0 |
| Writing Can Be Read Tactually | 3 | 3 | 3 | 0 | 0 | 3 | 3 |
| Can Use Braille To Make Result Match Intent | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Can Use Braille To Check If Result Matches Intent | 3 | 3 | 2 | 0 | 0 | 2 | 2 |
| Total Score | 25 | 27 | 20 | 16 | 17 | 23 | 23 |

## Notes on the Criteria

**Portability:** On the screen reader with braille display, the type of computer/phone device being used affects the portability; a phone paired with a small braille device scores higher than a larger computer.

For a computer with embosser, although some embossers and computers are more portable than others, this tool did not rank as portable by the portability standards of today.

**Cost:** Cost varies with braille display devices; lower cost devices have less features and braille cells.

A computer with embosser requires not only the computer and the embosser, but also a screen reader and braille translation software; no-cost screen readers and translation software have recently become available but may or may not have all of the features of their priced counterparts.

**Maximum achievable writing speed:** The computer with embosser scored lower here because of the delay between typing and availability of tactile dots.

**Surface Area Of Braille Accessible At Once:** Currently available refreshable braille devices primarily display a single line of braille but vary in their line lengths.

**Ease of Editing:** The tools that rank highest do so because of their word processing capability. Devices with multiple line refreshable displays may have potential for greater editing efficiency. Tools with tactile dots received a higher ranking.

**Ease of Communication with Non-Braille Readers:** For notetakers, this factor varies depending upon which features are included in the device. Some stand-alone notetakers are strictly braille-centric and require more steps to export the material into print; such devices would rank lower.

**Can Use Braille to Make Result Match Intent** and **Can Use Braille To Check If Result Matches Intent:**: Scores for different screen readers and notetakers vary on this factor because of differences in accuracy of translation from braille to print. For example, in some cases, because of errors in translation from braille to print, it is necessary to switch from six-key typing to QWERTY to achieve the desired result, which lowers the ranking. Functionality in this area can be improved as braille-to-print translation becomes more consistently accurate.

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