**Teaching Logic to blind students**

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**Abstract**

This paper is about teaching elementary logic to blind or visually impaired students. The targeted audience are teachers who all of sudden have a blind or visually impaired student in their introduction to logic class, find limited help from disability centers in their institution, and have no idea what to do. We provide simple techniques that allow direct communication between a teacher and a visually impaired student. We show how the use of what is known as Polish notation simplifies communication, and pedagogically is a great notation for a Braille reader.

**Keywords**: Teaching logic, learning disability, Nemeth Code, Polish notation.

**Introduction**

We (the authors) have been contacted by a blind student who is taking a major in Philosophy which requires a course in logic. He also wanted to pursue graduate studies in Philosophy and wanted to secure a decent background in logic to this end. The recommendation from the disability centre at his university advised him to replace the course entirely with one which covers similar or equivalent material or convince the department to drop the course from the required courses-list. We hope that our approach to teaching introductory material in logic will help avoiding similar administrative barriers by giving simple means for instructors and blind students to communicate directly, bypassing the complicated need for back-and-forth translation.

**Problems**

We first list what we think are the most salient problems in teaching elementary logic to blind students. These problems are probably not unique to logic. Some of our proposed solutions might apply in other fields, or some solutions in other fields we are not aware of might help address them.

**1- Symbolism**

Logic heavily relies on symbols that are not readily accessible to blind students, unless they are able to read print and can enlarge or magnify it. Braille readers can be taught special braille symbols that correspond to logic symbols, but these are part of the special braille code for mathematics, which in American braille is called The Nemeth Code. Braille readers with a mathematics background may already know much of this code, so they can simply learn the new symbols.

Unfortunately, technology introduces a new problem. Where blind and sighted people interact, it has become customary for them to rely on automated translation. The sighted agent writes an email or a text file, and the braille reader decodes this on a dedicated device and reads it in braille. Conversely, the braille reader can write a message in braille, translate it into a text file using the dedicated device and then send that text file to the sighted agent. This is very easy and has revolutionized written communication for the better. The problem is that some less standard symbols and less standard strings of symbols are not among the ones that can be automatically translated at this stage. These include much logical symbolism. The ampersand symbol ‘&’ can usually be translated in both directions and so can the disjunction symbol ‘∨’, if represented as a ‘V’. However, the horseshoe symbol ‘⊃’ sometimes used for implication is not usually visible to braille readers whose files are automatically translated. Sometimes, there is just a gap where a symbol should be. Sometimes, there is no gap. Sometimes, there is a symbol that the braille reader cannot decipher. It all depends on how the software works.

The way to get around this problem for a braille reader is either to have an intelligent, mathematically savvy, brailleist preparing the braille versions of files, or for a kind person with some logic training to *describe* the symbols verbally into a file that can be automatically transcribed. The former is better, if you know the braille counterparts of the symbols. The latter gives results like:

p [horseshoe] (q tribar r))

To repeat the basic point, logic symbols are not directly accessible to braille readers.

**2. Communication**

Sighted instructors are hardly ever braille readers and, as we have just noted, dedicated help is needed to get information flowing without loss. Universities have disability centres with people who can help with brailling exam scripts and assessments, but (a) this takes time and (b) it's quite likely that staff do not know how to transcribe logical symbols, adding an extra layer of complexity. This means that written communication involving logical symbolism has to be mediated, with the potential of leaving a blind student behind.

Verbal communication is only a partial solution. Aside from practical issues like finding a time to meet, or travel issues for a blind person, the help needed will for the most part be about the symbolism, differences between formulas, diagrams, proof techniques, etc. When answering logic questions in person, teachers will inevitably use symbols written on paper or on a whiteboard. Unless the blind student knows how to efficiently take notes, or some such like solution, blind students will not get quality answers to their questions.

The problem of communication is thus intertwined with that of symbolism, and a solution to the second problem requires a solution to the first. We will offer some short-term solutions that facilitate direct communication between the teacher and blind students. Some solutions are "quick and dirty", allowing with little effort effective communication, but not so effective on the long-term, should the student want to pursue logic further, or even professionally. We will discuss long-term problems faced by blind logicians and propose some solutions, based on experience, although a lot more variance may occur between blind or visually impaired individuals.

**3. Sighted centred pedagogy**

Elementary techniques for teaching, presenting and proving things in logic are not always appropriate for blind students, especially braille readers. We are thinking particularly about truth-tables, truth-trees, Venn diagrams and natural deduction, which are typically taught in introductory logic courses. They are to logic what diagrams are to geometry: visual aids for understanding, presenting or solving problems. But they are not essential to the discipline. That is, the visual aspect of the techniques is not what makes logic work. Indeed, professional logicians know how to represent them very abstractly, and actually resort to this abstract representation in the pursuit of their work. Visual representations are indeed useful for a sighted logician, and can be very helpful pedagogically, but they are hurdles for a blind student, brick walls put in front of what would otherwise be accessible to them. The visual pedagogical devices may thus act against blind students.

But helpful representations also exist for the braille reader. The layout of a truth table can be just as meaningful to a blind reader, accessing it by touch, as to a sighted one. After all, touch and sight are simply two ways to explore spatial relations among things and a two-dimensional grid with only two possible entries in each slot sets up a very straightforward set of spatial relations. The blind reader is just as likely as the sighted reader to understand that each row represents a possible assignment and that each column represents the possible assignments for a particular stage in the operation. Even if they don't understand this, both blind and the sighted readers can be taught the mechanical procedures for working out which values belong in which cells of the table and they can be taught how to interpret the results of this procedure: they can learn when to rule that an argument is valid, for example. Tactile and visual presentations are on a par here, because truth tables are very simple modes of representation. Working with an "old-fashioned" mechanical braillewriter and a large piece of paper, truth tables of moderate size can be produced by hand by the braille-reading student. As long as the sighted instructor explains the rules for the truth-table, a braille reader can produce tables and use them for proofs—and this can be rather congenial, though its effectiveness probably varies from student to student, just as it does with sighted people.

But there is a snag. Increasingly, braille readers rely on portable, dedicated, electronic braille devices. These typically allow for lines of braille that are less than 35 characters in length and the user can only access one line at a time. This means that a table cannot be read. Typically, the device has a "table mode" which gives one a choice of whether the line of braille on the display represents a row or a column. This is a far cry from the two-dimensional array that makes the truth-table such an intuitive form of display. So when it comes to truth tables, they can be pedagogically useful, but are almost impossible to implement technologically.

Truth trees perhaps have the worst problems. Though the idea of a branching tree is probably as intuitive for blind as for sighted people, a tree that consists of formulas is very hard to braille and quite difficult to read. This is true even before we start thinking about the technological complications. As a tree branches, more and more space on a horizontal line of braille is required to represent it and this balloons out of control rapidly and one quickly reaches the physical margins of the page. Even with a large sheet of braille paper, you quickly run out of room once you have to write three or four formulas across a row and there is no straightforward way of drawing lines between formulas to show which formulas have branched from which others. Professional brailleists can manage to present trees compactly and readably, but a student trying to complete an exercise, with no early inkling of how big the tree will grow, is facing an insurmountable task. Things get worse if you use an electronic braille-reading device, for two reasons. First, the typical length of a braille line is shorter than on a sheet of paper. As we noted earlier, it is less than 35 characters. Second, since the reader only has access to one line of braille at a time, the spatial layout of the tree cannot easily be discerned.

Venn diagrams are more like truth tables than trees, because they are pedagogically useful and if they can be embossed, a blind person can access them. This happens in some professionally brailled books. But technologically, they are even harder to tame than truth tables. They are not writing. They are diagrams, perhaps with writing in them. A braille-reading device cannot reproduce diagrams and certainly cannot display them.

Perhaps surprisingly, natural deduction is the least problematic of the techniques we are considering—as long as all the symbols are available. We will describe below a braille representation for propositional logic that can be used on electronic braille-reading devices. This representation is consistent with our solutions to the first two problems. One difficulty, as above, is that the braille reader can only read one line at a time and that makes it hard to scan a proof, but this problem arises for any kind of reading where one needs to move quickly back and forward to check earlier and later parts of a text.

**4. Technological obsolescence**

It's very easy for outsiders to think: well, technology means that translation is automated. So, if you are a braille reader, or somebody who gets text read out loud, surely the teacher just submits an electronic file to the machinery and it will spit out something a blind person can deal with. While we must acknowledge the huge benefits that technology brings to blind communicators, we have already seen that this is not correct, because of the difficulties with translating symbols.

There is also another difficulty. A braille reader needs technology that faithfully interfaces with the machinery being used by sighted people. Companies design new versions of operating systems (and new ways to navigate them) based on what is convenient for sighted users. The braille-reader is often presented (especially online, but also in handouts from sighted teachers) with stuff that looks beautiful, but feels awful. That's on a good day. On a bad day, the braille device cannot even translate the file, because the file has been created with a relatively new operating system. It is only very recently that braille readers have been able to accept and translate docx files and PDF documents. Very often, there is also a problem with back-compatibility. For a braille reader, it's very often "two steps forward and one and a half steps back". Of course, sighted readers are hardly immune to the frustration of upgrades that remove cherished features from their favorite applications and new operating systems can be a bit of a curse for everybody, even when they bring obvious benefits. So it is important not to make too much of this issue. The distinctive issue for blind users is simply that innovations in interfacing and preferences for software standardization are often driven by attempts to make things "look" better and what looks better sometimes "feels" or "sounds" worse.

**Proposed Solutions**

We have short-term (quick and dirty) solutions that will help a teacher address some of the most pressing problems we've outlined above, and we will then consider longer-term solutions, for more advanced students. We briefly describe them.

**Solutions to problems 1 and 2**

A quick and dirty solution that facilitates direct communication between the teacher and a blind student is to use Polish notation. Polish notation only uses the Roman alphabet. It's a symbolism that is readily accessible to both sighted instructors and blind students. It's easy to use in emails, and teachers can communicate directly with blind students without having to use disability centres as an intermediary.

Polish Notation is a method of writing logic devised by Łukasiewicz, a philosopher belonging to the Lvov-Warsaw School in Poland. Rather than representing logic sentences with infix notation (in which connectives are placed between propositional letters such as in "a or b") Polish Notation is written in prefix notation (in which the connective is placed before the propositional letters, as in "or a b"). Unlike infix notation, prefix notation does not require the use of parentheses. Furthermore, it is more conducive to the braille linear format, since a braille reader reads one phrase or letter at a time.

Besides using prefix notation, Polish Notation only uses upper and lowercase letters. It therefore escapes other forms of context-sensitive ambiguities that occur when certain dot configurations have more than one use or meaning within a braille notation or even within the same sentence. Finally, the meaning in braille of any string of letters in Polish Notation is exactly the same as the meaning in print. There is no need for third-party interlining and no difficulties in the translation of print material into the correct braille format, or vice versa.

However, if the student already knows the Nemeth code for mathematics, and if people at the disability centre know how to translate logic into the Nemeth code, this might be a better solution for the student. If the centre has enough time to transcribe assessment, notes and exam scripts, and this only requires teachers to send their notes in time, this would probably be the favoured solution. Its main advantage is that it enables the student to work directly with the same materials and exercises as the teacher and the rest of the class. Another advantage is that, should the student decide to pursue logic, this solution will need to be investigated anyway. One can't survive forever only in Polish. The main disadvantage of this Nemeth-based, braille-only system is that it is very unlikely that even fluent sited Nemeth brailleists would have enough time to translate a student's work back into print for the teacher to read. Our experience suggests that the blind student will either need to learn to type logic in an ordinary computer keyboard or dictate answers to exercises onto an audio recording. Polish notation overcomes this drawback completely. Teaching basic Polish Notation to the student may still facilitate communication.

We will describe how to use Polish notation in details below, with an application to natural deduction. Before that, we offer a solution to the third problem.

**Solution to problem 3**

**The Tennant-Spademan logic board for blinds**

On the Foundation of Mathematics e-mail list, Neil W. Tennant described the DIY construction a logic board for his blind student (<http://cs.nyu.edu/pipermail/fom/2001-April/004880.html>):

“I had a blind student taking Logic two years ago. We found there was \*nothing\* out there to help the blind learn logic. So I made a "logic board", which was a piece of 3-ply (8' by 4') covered with felt and with a support system that would hold it at an angle on a table. Then we had brass dyes made, of all the logic symbols that would be needed, from a LaTeX printout. (This was the expensive bit---about $1000 was spent on this.) With those dyes, we stamped out many sheets of embossed symbols. The individual tokens were then cut out, and backed with Velcro. Each token was about 1.5" square. We had a rough logico-alphabetical ordering of groups of symbol-tokens round the periphery of the board, and the student could then construct his formulae and natural deductions in the middle of the board.”

Tennant’s board builds on a very good and simple idea: to replace the visual aid with a tactile one that can be shared by both the teacher and the blind student. The board has been improved by Thomas Spademan in two respects: 1) making it easier and cheaper to build and 2) using the symbolism of Polish notation instead of an embossed representations of the logic symbols. Instead of using a 3-ply, Spademan used a magnetic board (the kind that can be bought at very modest cost at the corner shop), and instead of dyes, he used “little magnetic tiles on which I had printed the relevant symbols, and over which I used a Braille Dymo labeler with clear tape.” (private communication). This is much cheaper and easier to build than the original Tennant board. Having both the symbols printed on the tiles and embossed on clear tape makes tile readable to the teacher and students just like they would in print. Using Polish notation also means that the braille symbols are simple to read, as they are just standard Roman letters. It is also the same notation that we propose to use in email communication – don’t multiply notation if you can avoid it. The Tennant-Spademan board is thus easy to construct and allows direct interaction between the teacher and the student to build trees and proofs. This can be used alongside either of the other solutions, especially if the teacher can spend one on one time with the student.

**Polish Notation.**

We offer blind-friendly representations of natural deductions using Polish notation. With those, a student can write up answers in a simple text file and send them directly to the teacher for marking.

**Subsection Propositional Logic**

The language we build only uses letters from the Roman alphabet. Upper-Case letters are reserved for connectives, and lower-case letters for propositional or predicate letters, variables and constants. Interestingly, braille distinguishes between these simply by writing a single dot, the capital letter sign, in the cell immediately before the letter, turning it from lower-case into upper-case. So upper-case and lower-case versions of the same letter are represented in the same way, except that the former uses two characters and the latter uses only one. This in turn means that the braille capital letter sign functions in Polish notation as a way of indicating that what follows is an operator, rather than an operand. As there are only finitely many letters in the Roman alphabet, we describe a small language with only a few atomic symbols. A small language is all that is needed for teaching introductory logic, however, so no pedagogical problems occur with this choice — only an evil pedagogue would use more than 5 variables in a formula for an introduction to logic course!

The traditional Polish notation uses the upper-case letters C for implication, A for disjunction, K for conjunction, but we think that a different choice of letters is easier for English-speakers. Teachers of different natural languages are advised to choose a selection of upper-case letters for connectives that is more suitable for their language, as much as possible.

Reserve the lower-case letters p, q, r, s, and t for propositional letters. Use the upper-case letters N for negation, C for conjunction, D for disjunction, I for implication (or `if ... then ...'), and B for Bi-conditional (if and only if). Polish notation is a prefix notation, which means that we write Cpq for `p and q' instead of the infix notation pCq. So write complex formulas in the following way. Let f, g, h be arbitrary formulas:

|  |  |
| --- | --- |
| ‘NOT-p’ | Np |
| ‘p AND q’ | Cpq |
| ‘p OR q’ | Dpq |
| ‘IF p THEN q’ | Ipq |
| ‘p IFF q’ | Bpq |

For complex formulas, that is formulas that use more than one connective, leave a space whenever you introduce a connective other than N after a propositional letter. To illustrate this, contrast the two formulas ICpqr and Ip Cqr. The first formula says that if p and q are true, then r is true. The second formula says that if p is true, then q and r are true.

Here are some examples of various propositional formulas in Polish Notation.

1. p and (q or r): Cp Dqr.

2. If p then (if q then (q or Not-r))): Ip Iq DqNr.

**Subsection First-Order Logic**

For first-order logic, we reserve the lower-case letters x, y and z to stand for variables, a, b and c to stand for constants, l, m, n, o and p, for monadic predicates, and q, r and s for relation symbols. We reserve the upper-case letters A and E for the universal (all) and existential (exists) quantifiers. Adapt the language appropriately if you need ternary relations. Write px for monadic predicates, and rxy for binary relations. Write formulas in the following way:

|  |  |
| --- | --- |
| A is a P. (e.g., a is a plant) | pa |
| All x are people. | Axpx |
| Some x is people. | Expx |

For example, the formula AxEyIpxqy says that for all x, there exists a y such that if x is p, then y is q, and the formula AxIpx EyCrxyqx says that for all x, if x is p, then there exists y such that y is r-related to x and x is q.

How to instruct your student to read formulas.

The basic strategy is the same as for propositional logic. The left hand reads connectives and quantifiers, the right hand reads the arguments or connectives or quantifiers. So in Axfx, the left hand reads `all x', and the right hand reads 'are f'. When reading a predicate symbol with the right hand, read both the predicate and its argument, and likewise when reading a relation symbol, read the relation symbol and both of its arguments.

Here are some examples of how various logic sentences are constructed in Polish Notation.

1. Some p's are q's: ExCpxqx.

2. No p's are q's: NExCpxqx.

3. For every x, for every y, there exists z such that if x is N, y is N and x is related to y by R, then either z is Q or y is related to x by R: AxAyEzI Cnx Cnyrxy Dqzryx.

Sighted logicians will find these formulas ugly, but with little effort, they will be able to communicate directly with their blind students, and this is a significant advantage when teaching introduction to logic. Polish notation thus offers a short-term solution to the problem of communication with blind or visually impaired students, which is enough to get them through their introductory classes. For more permanent solutions, should your students want to pursue logic further, there are better tools available to a blind logician (for example learning the Nemeth code for mathematics). We will discuss long-term solutions below.

It is important to point out in example 3 the expression nx stands for a predicate letter applied to x and should be read as 'the property n holds of x'. It should not be read as 'not x', since it is written as a lower-case letter followed by a variable, and not as operator followed by variable — Nx is meaningless in logic.

**Section Natural Deduction**

We give an illustration of how Polish notation can be used in a braille-friendly notation for natural deduction. The goal is to illustrate how a sighted teacher and a blind student can share natural deduction proofs without the need of a third party.

A line in a natural deduction proof contains first a line number n, followed by a space, followed by a sequence of numbers separated by a comma and a space 0, 1, ... , m, followed by a space, followed by a formula f, followed by a space, and finally a justification. The justification consists of numbers followed by the initials for the name of a rule of inference. The numbers in the justification are separated from one another by a comma and a space. It thus looks like this:

n 0,1, 2, ..., m f justification

The first number n is simply the number of the line in the proof system, and the sequence 0, 1, 2, ..., m represents subproofs. A formula is proved when it is the last line of a deduction and every subproof has been closed, so when 0 is the only subproof number on the line.

The rule of conjunction introduction is written as, with f and g arbitrary formulas and i less or equal to j:

n 0,1, 2, ..., i f

...

m 0, 1, 2, ..., j g

m plus 1 0, 1, 2, ..., j Cfg nmCI

with nmCI standing for n-m-conjunction-introduction.

The rule of implication introduction, using subproofs, is given by:

n 1, 2, ..., i f assumption

...

m 1, 2, ..., i g

m plus 1 1, 2, ..., i-1 Ifg nmII

with justification nmII standing for n-m-implication-introduction.

As an example, the proof for the thesis Ip Iq Cpq looks like:

1 0, 1 p assumption

2 0, 2 q assumption

3 0, 2 Cpq 12CI

4 0, 1 Iq Cpq 23II

5 0 Ip Iq Cpq 14II

**Specialised logic braille**

Using Polish notation or a braille board are flexible ways of introducing students to logic. They are technologically easy to implement. They solve the communication problem between teacher and student. They allow the student to work with braille, without introducing a lot of new braille symbols that the teacher cannot read. They do not rely on presentation styles that assume sight. They will not suffice, however, if a student is to continue in logic.

More advanced logic requires students to learn a variety of presentation and proof methods, so they will not be able to make do with Polish notation. It requires them to be able to read textbooks and sometimes journal articles, so these will need to be made accessible to them. It also requires them to see that the methods of logic are continuous with those of mathematics and that logic has interesting relationships with set theory, algebra, arithmetic, analysis and (if one stays in the game long enough) geometry and linguistics.

It seems to us that there is no substitute for ensuring that the student learns the specialised mathematics braille. Students who have encountered relatively advanced high school mathematics (such as trigonometry and calculus) are likely to know mathematical braille. These students will need to learn the extra logic symbols, but this is not difficult. Of course, many students come to logic without very much mathematical background. When such students are blind, there is a steep learning curve if they find they enjoy logic. They will have to decide whether they enjoy logic enough to justify learning mathematical braille and the specialised logic symbols.

There are different braille mathematical codes in different countries. The American one is called Nemeth Code, after its inventor, Abraham Nemeth. It is used also in other countries including New Zealand. It is not straightforwardly an extension of ordinary literary braille. It is a completely different code. In ordinary English prose, I might write: "There were 7 donkeys and I bought an extra 2. (7 plus 2 is 9, I believe.)" This would be written in ordinary literary braille. However, if I wished to write: "(x squared plus 7x plus 9) divided by 2 equals 0" in a mathematical context, the Nemeth would be completely unrecognisable to a braille reader who has not learned it. Even the numbers "7" and "9" are written with different braille symbols in Nemeth from the ones used in literary braille. So are the two parentheses. This may seem perverse and it does to some Nemeth learners too. However, the result is a fantastically flexible mathematical notation. One way to see why is to think specifically about the parentheses and note two features. First, parentheses in ordinary prose, braille or print, are used to screen a sequence of words off from the main sentence, allowing for the possibility that it does not fit neatly into the sentence syntactically. Parentheses indicate an aside. In mathematics, they do a completely different job: they indicate the scope of an operation and hence, the order in which operations are to be performed. Nemeth braille readers have an advantage over sighted mathematicians. These two functions are marked by two different sets of symbols, so a conceptual distinction is evident from the braille symbolism that is not evident in print. Second, in ordinary, literary braille, the symbol for opening parentheses is the same as the symbol for closing parentheses. In lengthy formulas, this can be very confusing to a braille reader. In Nemeth braille, the two symbols are different, so it is much easier to see whether your parentheses are opening or closing.

Armed with a special mathematical code, a blind logician can read, prove and write efficiently and it is unclear how else this could be managed. The down-side is that technological and communication problems return. We already explained why when we set out the original problems. Translation to and from mathematical braille is not automated as yet. This means that books and articles have to be translated from print by brailleists with a background in mathematics and that blind logicians cannot easily convey the content of what they produce to the sighted logic community. Here are three ways to address the latter problem.

First, the blind logician can make audio recordings, dictating what is written down in braille and then engaging somebody else (a teacher, another student, or a friend) to transcribe from the recording. Second, the blind logician can translate from the Nemeth into a form of braille that does not contain symbols, but could be understood by any print reader who knew logic. As noted earlier, the sighted reader could expect to encounter strings of text like the following:

(p horseshoe universal x existential y (Fx ampersand Gy))

Third, the blind logician may be able to type logic symbols on an ordinary computer keyboard. This is rather fiddly, but it can be done with a lot of patience. The main skill here is probably that of manipulating fonts. A screenreader with a voice synthesizer or a braille display that reads special "computer braille" will almost certainly need to be connected to the computer so that the blind logician can monitor what is being inputted and read it back. This third solution, insofar as it can be implemented, is the only one that really facilitates direct communication between the blind writer and the sighted reader. However, it is not so good for the reverse process. It is very difficult for a blind computer-user to read strings of logic symbols from a computer, either with audio, or with braille read-out. We are not claiming that it is impossible. (There are some very talented blind computer users, including professional programmers.) But it is quite a challenge.

**Dos and don'ts**

We finish the paper by providing some dos and don'ts that we think can help teachers being more inclusive of blind students in their teaching environment.

**Dos**

1- Say out loud everything you write on the board (including brackets!).

2- Record your lectures.

3- Allow students to submit assignments in audio. They can recite their answers.

4- When communicating by email, format in plain text and avoid long email threads. Do not refer to something that was said some emails ago by saying, like sighted people would do: "as I said in a previous (see below), bla bla bla". If you need to refer to something that was said in a previous email, copy it!

5- When verbalising what's on the board, take care always to use the same words. Don't move freely between "implication" and "conditional". A sighted student may take note of the fact that you are associating the same symbol with the two words, but a blind student may worry. You can, of course, say at some point that the word "conditional" is sometimes used instead of "implication".

**Don'ts**

1- Don't try to help blind students visualise symbols. I (author identity left out for blind referee) once tried to draw an arrow in my student's hand, only to realise how useless that was. As simple as an arrow looks, it actually is very complex to visualise for a blind person and doesn’t help the student understand what implication means or how it functions. Even though the common symbol for implication is referred to as a horseshoe, it does not help a blind person to say that the symbol for implication looks like a horseshoe tilted on its side. Of course a blind person may be curious to know what symbols are like, and although not easy, one can describe and make sense of symbols for a blind person. What you don't want to do, however, is to try and get blind students to see symbols as you do.

2- Don't try to draw symbols using braille symbols. A sighted person looking at braille symbols can think of drawing an arrow: use two squares, draw the tail of the arrow in the first square and the arrow-head on the second square, and voila! The problem is that you have now used two braille characters, the punctuation colon symbol followed by the letter `o', and cono does not look like an arrow! Again, a blind student might become interested in the shape of the symbols, but it does not help with learning logic.

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