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The Pashai Counting System in Comparison to Other languages: The Reason for Introducing Finger Math

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Abstract: **Finger Math is an effective method of learning math to prevent math phobia and dyscalculia. It gives children confidence and competency in math and lets them do logical thinking through practicing multisensory strategies; its stimulation brings more balanced and holistic academic development for children in minority language groups. It is more effective if introduced when the children are under 8. The complexity of the Pashai numeral system has led many Pashai children to have math phobia and dyscalculia from the beginning of their schooling. However, these difficulties have almost disappeared since the Pashai language development project introduced the finger math program in the region of the eastern zone of Nangarhar Province, Afghanistan.**

Keywords: **Finger Math (or Finger Abacus), vigesimal numeral system, decimal system, math phobia & dyscalculia, balanced and holistic academic development, multisensory strategies, Mother Tongue-Based Multilingual Education (MTB-MLE), ethnic minorities.**

1. INTRODUCTION

Ethnic language minority children face challenges when they deal with mathematics even with their own language and counting system. Further problems may arise when it comes to counting in other languages' counting systems, such as school languages. For example, English has no systematic rules for naming numbers. Specifically, "10" is followed by irregular numbers "11" and "12", followed by regular numbers such as "13", "14", and "15" with '-teen'. So, if one does not know the irregular words "eleven" and "twelve," they won't be able to guess them systematically. In the case of Pashto, the official language of Afghanistan, the counting system is similar to or simpler than English. For example, in Pashto, "10" is 'las'; "11" is 'iyao-las'; "12" is 'dwo-las'; "13" is 'dyaar-las'; "14" is 'caar-las'; "15" is 'pinZə-las' and so on, which has no irregular cardinal numbers like "11" and "12" of English in Pashto. However, the Pashai language has a vigesimal counting system. It is very complex and challenging to transfer from the Pashai system to other language systems. This paper especially shows the literal translations of the juxtaposed counting systems, the barriers of learning math, and the reason for introducing 'finger math' (Finger Abacus) to the Pashai children.

Counting logic and numeral systems

Consequently, for some ethnic minority children who are not exposed to outside world, words like "one-teen" would probably come to mind for "11" for the English numbers. In the meantime, children may unconsciously but logically try to make the pattern more regular by arranging words like "five-teen" for "15" and so on. It's like the process of making grammatically similar errors that young children go through when learning a language (Selinker[1],1972).

More confusingly, some English words reverse the order of their numbers. For example, the cardinal number "fourteen"

[1]Selinker mentions that 'when learners learn a second language, it is similar to the error correction process of young children learning their first language.' And he named it as a process language or interlanguage. In other words, the interlanguage that appears in learning the target language is the language that second language learners make while learning the target language, and it is explained that it is neither a target language nor a native language but a developmental systematic language (1972).

calls the "4" in the number "14" preceded by the tens digit. However, for multiples of "10", English speakers switch to other patterns, such as "twenty," "thirty," and "forty." In the case of Pashto, counting is the same as English for multiples of "10". Therefore, it may take time for children to learn all these words and understand that "13" differs from "30".

There are some different numeral systems in the world. However, the most common numeral system is the decimal system, in which each number is represented by its base 10. If the base is 2, it is a binary number; if the base is 20, it is vigesimal. The conversion of decimal numbers to any other number system is an easy method. However, to convert other base number systems into decimal numbers requires practice. The decimal system could be developed based on countable numbers of our fingers; compared with the decimal system, the vigesimal numeral system is developed based on our fingers and toes' numbers, which are easily visible and countable.

The Pashai numeral system, in comparison with other languages' numeral systems

In Pashai, one of Afghanistan's ethnic minority languages, the counting and numbering system is much more complex than the system of other languages. For example, from "11 to "19," numbers are irregular, such as '*yaai*,' '*dwai*,' '*łue*,' '*cade*,' '*painʐu*,' '*ʃoɣ*,' '*satu*,' '*aʃʈu*,' and '*nəu*.' It is one of the reasons why Pashai children face more difficulties with counting or math. Many children have suffered from math phobia. This phenomenon serves as the motivation behind introducing 'Finger Math' (Finger Abacus) to the Pashai multilingual education. Finger Math uses the human senses through systematic finger movement. It is simply using fingers for the four fundamental arithmetic operation and associated logic (math logic).

The Pashai method of counting numbers is like using vigesimal in French. French cardinal numerals are named more or less consistently up to "60," after which the system changes to the so-called vigesimal structure. 'Vigesimal' is based on multiples of "20." So, native French-speaking children struggle with the English counting system compared to English-speaking children[2]. For example, the numbers for "70," "80," and "90" in French are unique. "70" in French is '*soixante-dix*,' which literally means "sixty-ten." "71" is counted as, '*soixante et onze'* (60-11), which is "sixty and eleven"; followed by, '*soixante-douze'* (sixty-twelve), '*soixante-treize'* (sixty-thirteen), '*soixante-quatorze'* (sixty-fourteen) and so on, all attached by hyphens. This process is called 'transcoding,' which means correctly converting words to numbers and vice versa. For example, "71" is read as its ten-digit first in English, followed by one-digit with the vigesimal system. So, it reads as "seventy-one" as 'sixty-eleven' in sequence[3]. However, when English speakers learn the number system, they also face difficulties in comparison with Korean, Chinese, and Japanese learners. In other words, the latter cases have more clear math concepts than English, making it easier for small children to learn counting and math, research shows[4].

In the French counting system, "80" is '*quatre vingts,'* literally, "four twenties." After this, "81" is *quatre-vingt-un*, "82" is *quatre-vingt-deux*, respectively, "four twenties and one" and "four twenties and two," and so on. As for "90," which, in French, is '*quatre-vingt-dix,'* means "four twenties and ten." From there, "91" is '*quatre-vingt-onze'* ("four twenties and eleven"), "92" is '*quatre-vingt-douze'* ("four twenties and twelve"), and so on.

Language	17	27	71
English	'seventeen'	'twenty-seven'	'seventy-one'
Korean	'ten-seven'	'two-ten-seven'	'seven-ten-one'
Chinese	'ten-seven'	'two-ten-seven'	'seven-ten-one'
Turkish	'ten-seven'	'twenty-seven'	'seventy-one'
Pashto	'seventeen'	'twenty-seven'	'seventy-one'
French	'seventeen'	'twenty-seven'	'sixty-eleven'
Pashai	'seventeen'	'twenty-seven'	'three-twenties-eleven'

(Table 1: Literal Translation for numbers-cardinal numbers- among comparison languages)

In the region of Dara-i-Noor, where the Pashai people live, Pashto is the instructional language of school. Its numbering system is regular and similar to Korean, but Pashai is identical to the vigesimal system similar to French. Pashai counting also uses the vigesimal system. For example, "30" is '*westo-de,'* which is 'twenty and ten' (20-10); "40" is read as 'd*eweyaa*,' which is 'two twenties' (2-20); in the case of "41," '*deweyaao-i"* two twenties and one (2-20 &1). The following Table 1 shows the earlier compared languages' literal translation for numbers.

[2] https://storylearning.com/learn/french/french-tips/french-numbers
[3] Ibid.
[4] https://www.wsj.com/articles/the-best-language-for-math-1410304008

Pashai Cardinal Numbers in Pashai Orthography with IPA

Pashai Cardinal Numbers in Pashai Orthography with IPA	Pashai Numbers	Pashai Cardinal Numbers	Values (from 1 to 10)
i	١	اي	1
do	٢	دُو	2
ɬe	٣	ڵی	3
caar	۴	چار	4
painZ	۵	پَینج	5
ʃe	۶	شی	6
sat	٧	سَت	7
aʃt	٨	اَشت	8
no	٩	نۆ	9
de	١٠	دی	10
yaai	١١	یای	11
dwai	١٢	دوَي	12
ɬue	١٣	ڵوی	13
cade	١۴	چَدی	14
painZu	١۵	پَینجو	15
ʃoɽ	١۶	شُوڕ	16
satu	١٧	سَتو	17
aʃʈu	١٨	اَشټو	18
nəu	١٩	نَو	19
west	٢٠	وېست	20
westo-i	٢١	وېستۆ اي	21

(Table 2: Pashai numbers from 1-21)

Cardinal Numbers of Pashai with IPA	Counting Mechanism	Pashai & Pashto Numbers	Pashai Cardinal Numbers	Values
westo-de:	*20 -10*	٣٠	وېستۆ دېی	30
westo-yaai	20-11	٣١	وېستۆ یای	31
westo-dwaai	20-12	٣٢	وېستۆ دوای	32
deweyaa	2-20	۴٠	دېوېیا	40
deweyaao-i	2-20 & 1	۴١	دېوېیاۆ اي	41
deweyaao-do	2-20 & 2	۴٢	دېوېیاۆ دُو	42
deweyaao-dee	2-20 & 10	۵٠	دېوېیاۆ دېی	50
deweyaao-yaai	2-20 & 11	۵١	دېوېیاۆ یای	51
deweyaao-dwaai	2-20 & 12	۵٢	دېوېیاۆ دوای	52
ɬeweyaa	3-20	۶٠	ڵېوېیا	60
ɬeweyaao-i	3-20 & 1	۶١	ڵیوېیاۆ اي	61
ɬeweyaao-do	3-20 & 2	۶٢	ڵیوېیاو دُو	62
ɬeweyaao-dee	3-20 & 10	٧٠	ڵیوېیاو دېی	70
ɬeweyaao- yaai	3-20 & 11	٧١	ڵېوېیاو یای	71
ɬeweyaao-doaai	3-20 & 12	٧٢	ڵېوېیاو دوای	72
car-weyaa	4-20	٨٠	چار وېیا	80
caar-weyaao-i	4-20 & 1	٨١	چاروېیاو اي	81
caar-weyaao-do	4-20 & 2	٨٢	چاروېیاو دُو	82
caar-weyaao- dee	4-20 & 10	٩٠	چار وېیاو دېی	90
caar-weyaao-yaai	4-20 & 11	٩١	چار وېیاو یای	91
caar-weyaao- dwaai	4-20 & 12	٩٢	چاروېیاو دوای	92

(Table 3: The Pashai vigesimal system and ways of writing: Pashai numbers & Cardinal numbers, their values from 30 to 92, counting mechanism and cardinal numbers' counting in IPA[5])

[5] The International Phonetic Alphabet (IPA) is an academic standard created by the International Phonetic Association. IPA is a phonetic notation system that uses a set of symbols to represent each distinct sound that exists in human spoken language.

Finger Math

Finger Math is a method of learning math that is an effective tool to prevent dyscalculia. It gives children confidence and competency in math and lets them do logical thinking through practicing multisensory strategies; its stimulation brings more balanced and holistic academic development for children in minority language groups. It is more effective if introduced when the children are under 8 (Boaler et al., 2016[6]). As mentioned above, the complexity of the numeral system of the Pashai has led many Pashai children to have math phobia and dyscalculia from the beginning of their schooling. However, these difficulties have almost disappeared since the Pashai language development project introduced the finger math program in the region. Because of its effectiveness, the regional school masters asked the MTB-MLE program supervisors to train their teachers to be equipped with finger math strategies and teaching skills. The Pashai language project has been training government school teachers since 2010.

A brief explanation for Finger Math: it is a mathematics method that interactively teaches students mathematics. Students make use of all their senses with this method. It uses **multisensory strategies:** instruction links visual, auditory, and kinesthetic-tactile modalities. Learning occurs when the students do physical activities rather than listening to a lecture or watching demonstrations. And these modalities are linked with the user's brain through the nerve system. Learners simultaneously connect what they see with what they hear and feel.

In some cases, especially in very basic education and living circumstances such as in remote minority language areas, mother-tongue literacy only and multilingual education can be only partial solutions for their holistic and academic development. Finger math is a useful tool for teaching basic arithmetic to students, especially those from ethnic minority groups. Here are some steps you can take to apply finger math for mother tongue-based multilingual education:

1) Introduce the concept: Start by introducing the concept of finger math to the students. Show them how to use their fingers to count, add, subtract, and multiply.

2) Demonstrate the technique: Demonstrate the technique by using a whiteboard or chart paper to show how to use fingers to perform basic arithmetic operations. Use simple examples to illustrate the technique.

3) Practice with students: Allow the students to practice the technique by working on simple arithmetic problems. Finger Math will help them to become more familiar with the technique and gain confidence in using it.

4) Use mother tongue language: Use the students' mother tongue to teach finger math. Finger Math will help the students to understand the concept better and improve their language skills.

5) Provide feedback: Provide regular feedback to the students to help them identify their strengths and weaknesses in using finger math. It will help them to improve their performance over time.

6) Create engaging learning materials: Create engaging learning materials such as charts, posters, and videos to help students understand and practice finger math. These materials should be in the student's mother tongue to make them more accessible and practical.

7) Make it fun: Make finger math fun and interactive by incorporating games and competitions that motivate students to use the technique. It will help to make learning more enjoyable and engaging.

In summary, to apply finger math to mother tongue-based multilingual education for ethnic minority groups, you need to introduce the concept, demonstrate the technique, practice with students, use mother tongue language, provide feedback, create engaging learning materials, and make it fun. By following these steps, you can help students improve their arithmetic skills and build their confidence in using their mother tongue.

2. CONCLUSION

It is a realistic result that Pashai children struggle with numbers and math due to the complexity of their vigesimal numeral system. However, it is not just the Pashai children who have difficulties dealing with mathematics. According to Science Magazine's research (May 2011), dyscalculia patients make up 7 % of the world's population; even up to one in five people

(https://www.ipachart.com/)

[6] https://makingmathmakesense.org/wp-content/uploads/2019/09/Seeing-As-Understanding-Visual-Mathematics.pdf

may have a form of dyscalculia. In the case of minority language groups, especially for children who live in a place with a very basic education, this symptom is more common. In this situation, Finger Math allows ethnic minority children to have fun doing mathematics; steering them away from their fear of numbers. Also, using the five senses captivates them, as the total physical response (TPR[7]) gives the learners a fun and optimistic learning atmosphere in language learning. So, it raises confidence in math abilities so that the learners can "open doors" to new information.

Moreover, it is economic because it doesn't require much funding for making teaching and learning materials. In other words, it is cost-effective in that it doesn't require much time to train teachers, and already existing teachers can easily become the finger math teachers within one or two weeks' intensive training.

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[7] Total body response (TPR) is a method of teaching language or vocabulary concepts using physical movements to respond to verbal input. James J Asher, an emeritus professor of psychology at San José State University, developed it. TPR took from children's learning process for their native language, reducing student inhibitions and lowering stress. (https://www.teachingenglish.org.uk/professional-development/teachers/managing-lesson/articles/total-physical-response-tpr)