INDIAN PEDAGOGY AND PROBLEM SOLVING IN ANCIENT THAMIZHAKAM

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ABSTRACT

Indian pedagogies are not well known to research community outside India. The researcher refers to Indian literature to examine the pedagogies that have been in use in India since ancient Vedic times. She also identifies the use of these pedagogies even in contemporary classroom. She concludes that some of the current pedagogies such as memorization are culture-influenced pedagogies, culture being defined as a human learned behaviour.

Though pedagogies such as memorization and oral repetition which are considered in modern times as not very beneficial in enhancing the learners' intellect were used in ancient India, the researcher cites that how problem solving was part of the mathematics curriculum in Thamizhakam (Southern India), the province in which the mathematician Ramanujan was born. The researcher also cites how mathematics was taught and learnt in Thamizhakam. She quotes some of the ancient problem solving questions, which were transmitted orally for generations. She concludes that though traditional methods such memorization and oral repetition were in use in Indian mathematics classrooms, problem solving was also part of mathematics curriculum in Thamizhakam, which could have galvanized the mathematical reasoning of the learners.

Keywords: Indian pedagogy, problem solving, Indian culture in education

1 Introduction

Due to the phenomenal growth in the number of schools, the literacy rate in India has risen drastically in the past 50 years. According to the census of 2011, 821 out of every 1000 men and 655 out of every 1000 women could read and write (Department of School education). Guo (2005) praises India on witnessing "phenomenal educational development both in quantitative and qualitative terms, since independence" (p. 190). However, there are not many classroom studies on Indian classrooms focusing on teaching and learning.

Though India has produced many mathematicians, the pedagogy used in India is a mystery to many researchers as India did not take part in any international studies and there are not many studies on Indian pedagogies known to research community outside India. The researcher refers to literature to examine the pedagogies used in India and identifies certain key characteristic pedagogies such as oral transmission of knowledge, teacher questioning, memorization and oral repetition that have been in use since ancient Vedic times. The researcher also cites how mathematics was taught and some of the problem solving questions used in ancient Thamizhakam, the Tamil speaking part of South India,

which could explain how the two extremes of the spectrum of pedagogy complemented each other in the development of students' mathematical abilities.

2 Hallmarks of Indian Education

Each country has its own philosophy of education. Unlike the educational philosophies of Greece and China, which separated education and religion, in Indian educational philosophy, they were intertwined to the extreme that "music and poetry became even handmaids to religion" (Venketeswara, 1980, p. 31). Mathematics known as Ganita was mainly used in ancient India to calculate auspicious time to perform religious rituals and prayers based on the movement of planets and to build temples and altars. On analyzing the pedagogy of Indian primary schools, Alexander (2000) deduces that developing character is more important in India than enhancing intellect. According to Asthana (2001), the main function of education in India "to develop virtues, socially accepted thoughts and habits" (p. 2). In the ancient Indian education system, "Culture not literacy, was the highest aim of education in India" (Venketeswara, 1980, p. 24).

2.1 Borrowing others' ideas and indianizing

Venketeswara (1980) claims that the main feature of Indian education was its comprehensiveness as the curricula never excluded anything unfamiliar or new. According to him, "the expansiveness of Indian culture was the adaptability of the old to altering conditions and new circumstances"(p. 26). Since ancient times, the Indians readily accept new things "without completely ringing out the old" (ibid: p. 27). In their quest to search the truth, the Indians readily accept foreign doctrines. Venketeswara (1980) suggests that the immensity of Indian culture is due to "a readiness to borrow" (p. 25) and an adaptation of the borrowed ideas to the conditions and climate of their own country. "Astronomical terms were borrowed, they were skillfully Sanskritised and incorporated in Indian Astronomy that they became flesh of its flesh and bone of its bone"(ibid: p. 26). Venketeswara (1980) claims "the expansiveness of Indian culture is illustrated by a readiness to borrow, and an adaptation of the borrowed details to the conditions of this clime and country" (pp. 25–26) and "the adaptability of the old to altering conditions and new circumstances" (p. 26). The Indian educators have borrowed the doctrine of constructivism and have introduced activities in mathematics teaching in recent years. However, to maximize the success rate of students benefiting from the activities, the activities are transformed into teacher-directed activities. The main aim of the activities is to make every one including the average and below average students understand the mathematical concepts. In other words the activities supplement the whole class teaching but are not substitute to teaching. Though we can notice the introduction of collaborative learning, the use of ICT for learning and the use of activities to teach mathematics concepts in Indian classrooms, we can also observe the ancient pedagogies such as the stress on memorization, mental computation, questioning and even oral repetition in late 20th and 21st century Indian classrooms. This shows how the Indian society values ancient pedagogy though welcomes some changes in teaching methods for the benefit of the students.

3 Prominent Pedagogies of Teaching and Learning in India

3.1 Learning by listening

In ancient India, knowledge was transmitted orally. Though the art of writing was developed, the teaching was mostly depended on verbal learning (Chatterjee, 1951, p. 189). Learning by listening in India has been mentioned by Venketeswara (1980), "India stands alone in the emphasis of Sruti, learning by the ear, even long after writing came into common vogue"(p. 25). Even *Kautilya*, the chief advisor to the first Maurya Emperor in his book on politics *Arthasastra* (written around 300 B.C.) sums up the object of study as follows:

"**From hearing ensues knowledge**, thence *Yoga* (steady application), thence *Atmavatta* (self possession) (as quoted in Venketswara, 1980. p 164, emphasis added).

As oral pedagogy was predominant, listening to learn became indispensable. Venketswara (1980) claims that " both in Hindu and Buddhistic schools, instruction was oral; text-books were seldom used" as Fa-Hien, a Chinese monk who visited India in 4th century "could not find a single copy of the precepts in North India, where teachers trusted entirely to oral tradition" (p. 213). It is proposed that most of the learned books might have been written by the 17th century only. In South India known as *Thamizhakam* "the children began their lessons in mathematics with the learning of Tamil numerals, **by hearing** the number names" (Senthil Babu, 2007, p. 25). Only some teachers had text books called 'Ponnilakkam' (ibid.).

The significance attached to learning by listening in Tamil Nadu, the southern part of India can be understood as *Thirukural* ackowledges the knowledge attained by listening as the prime knowledge.

செல்வத்துள் செல்வம் செவிச்செல்வம் அச்செல்வம்
செல்வத்துள் எல்லாம் தலை.

(Kural. 411)
(Translation: Of all wealths, listening is the best available wealth on earth.)

Subramanian (2007) confirms that people followed this practice by stating "the pattern of education in ancient Tamilakam (Thamizhakam) was not merely reading and understanding of texts, but also listening to learned persons" (p. 342).

3.2 Questioning as one of the main pedagogies

Questioning has been employed as the main teaching methodology even in ancient India. There were frequent mentions of terms like "*prasnin*" (questioner), "*abhi—-prasnin*" (cross—questioner), "*prasna—vivaka*" (answerer) (Gupta, 2007, p. 76). Many past studies have identified the Indian teachers' use of questioning in mathematics classroom (Alexander, 2000; Clarke, 2001; Clarke & Fuller, 1997; Rao & Cheng, 2001). Clarke and Fuller (1997) have reported observing the teachers in Chennai transmitting "what the students should know" by lecturing and "how they should know" (p. 54) by asking questions. Clarke (2001) has also identified "the teacher asking questions and the student answering" (p. 77) as the predominant model of interaction between teacher and student in mathematics teaching. Alexander's (2000) research throws light on Indian teachers' efforts to develop dialogue with students and scaffold understanding despite the crowded classroom (p. 558) with the help of ques-

tioning. Rao and Cheng (2001) have found the Indian teachers use of questioning "to involve children actively in the learning process" (p. 11). Sensarma (2007) has identified 'question-answer dominated interaction pattern' as one of the seven commonly used distinctive interaction pattern in mathematics classrooms at secondary level. Subramanian's (2010) research analyzes extensive use of questioning in Indian mathematics classroom both to assess and assist students' learning. Since ancient times, discourse, questioning and debate have been commonly practiced pedagogies in India, which could explain the natural prevalence of this type of verbal interaction in the classrooms even today.

3.3 Memorization as a pedagogy

The Vedas, the oldest texts of Hinduism, have been transmitted orally for three thousand years as "the Vedas as recited from memory by Brahmans" (Fuller, 2001, p. 1) were considered as authoritative. The priests needed to learn texts from the Vedas even before mastering the Sanskrit language. Hence memorization became the dominant pedagogy used in the Vedic period (1500 B.C.–500 B.C.) Repetition (*parayana*) and memorization (Venketeswara, 1980) were renowned pedagogies as Vedas were repeated every day so that students could learn and remember the texts.

Students listened to the guru and repeated his utterances without the aid of books and memorized the Vedic texts. Venketeswara (1980) even claims that there were prayers for memory in ancient India.

> As regards methods of education, the first noteworthy principle is that of memorizing and even learning by rote. There are prayers for memory (*medtha*). 'May the Lord endow me with *medha*; may we learn much and learn by the ear, and may we retain what we have learnt' (p. 88)

Ancient Indian mathematical works, mostly composed in Sanskrit, usually in *the form of Sutras* in which a set of rules or theorems were stated in verse in order to aid memorization. "Profuse use of the verse style as an aid to memory and to make the students learn verbatim" (Bara, 1998, p. 161) clearly exhibits the society's belief in this pedagogy of learning. There was a strong stress on memorization of multiplication and conversion tables involving fractions and measurements in *Thamizhakam* where merchants memorized "all kinds of tables relating the various kinds of measures was the first task to be accomplished" (Samuel, 2005a, p. 59) to master arithmetic.

Kanita Nul (an ancient mathematics book in Tamil, recorded in palm-leaf manuscript) proves the significance attached to memorization to learn arithmetic in Thamizhakam (Samuel, 2005a). Senthil Babu (2007) claims that memory the mode of learning was central to education in the indigenous schools in Thamizhakam. He further asserts that memory was used not because of the lack of books but mainly good memory was considered as intelligence. Studies also show the presence of memorization as the common pedagogy in Indian classrooms even during the British period and the British could not as do much as the pedagogy has been deeply rooted in the Indian pedagogy (Clarke, 2001). The Vedic mathematics, which has been drawing a lot of attention in recent years, expounds the memorization of certain computation procedures to perform complex computation mentally. Memorization was a foundational pedagogy of learning in education systems in most cultures in ancient times; it is venerated in certain cultures, especially in India even today.

3.4 The use of oral repetition since the Vedic period

The dominant Pedagogy used in Vedic period (1500 B.C.–-500 B.C.) was repetition (*Parayana*) and memorization (Venketeswara, 1980). Vedas were chanted every day so that students could learn and remember the texts. Oral transmissions of texts were promoted, as the pronunciation of the texts with accuracy and correct intonation could not be achieved by learning from the texts. The pedagogy of oral repetition was not changed even under the Muslim rule, as "the oral transmission of the Quran" was "the backbone of Muslim education" (Robinson, 1996, p. 65). The numerical tables were recited twice a day in order to memorize them (Acharya, 1996). When there was a scarcity of textbooks and when many could not afford to buy textbooks, oral transmission of texts became inevitable and oral repetition became a strategy to memorize the texts and to pass on to the next generation. However, it is worth mentioning that even written texts are readily available at affordable prices, people prefer the oral transmission of knowledge. Oral repetition became an effective strategy when oral tradition was widely used. Oral repetition, which was one of the common pedagogies in ancient times, is still in use in Indian classrooms (Alexander, 2000; Clarke, 2001; J. Subramanian, 2010).

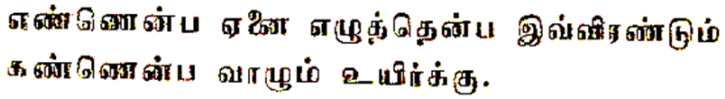
The researcher summarizes that stress on oral tradition, teacher questioning, oral repetition and memorization are pedagogies being in practice in India since ancient times and hence they are influenced by culture as these practices are 'learned behaviours', being transmitted socially.

4 History of Education in Ancient and Medieval Thamizhakam

The Tamil (a language) speaking community was formed nearly thirty five centuries ago (N. Subramanian, 1996) and lived in the southern part of Indian peninsula which is currently known as Tamil Nadu. Originally this part of India was known as *Thamizhakam*. As we find great quality of poetic literature, we understand that creativity was celebrated by the Tamils. At the same time, "the merchants and the royal servants were to learn accounting and arithmetic" (N. Subramanian, 2007, p. 343). We do not know much on curriculum or pedagogy. Subramanian (ibid) claims, "Much of the teaching was oral" (p. 345). Many literary pieces were saved due to the remarkable memory of the students of those days, as they did not have any other aids to preserve the literary texts. The students memorized the texts not only because there was a scarcity of textbooks but mainly because "it was believed that a strong memory was a chief virtue of a scholar" (ibid. p. 345).

4.1 Significance attached to Mathematics in Thamizhakam

The ancient Tamil literature, Thirukural (also known as Kural) proclaims numeracy and literacy as the two eyes of human being.



(Kural.392)
(Meaning: Numeracy and literacy are considered as eyes for living creatures.)

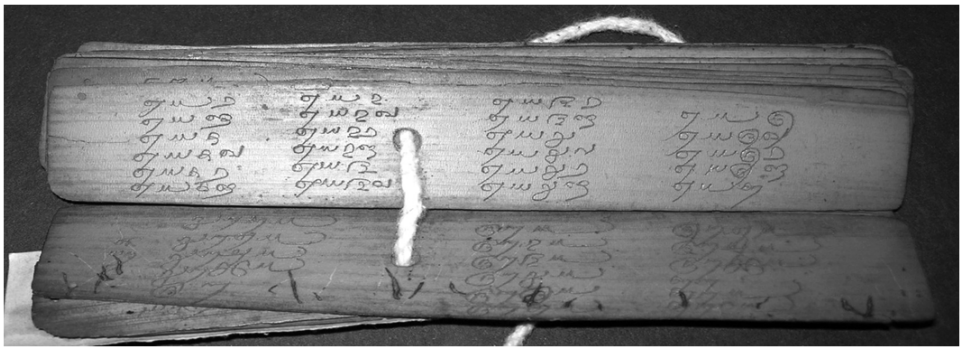
In Western literature, we come across literacy and numeracy. However, in Tamil Nadu since ancient times, numeracy (*en*) is mentioned before literacy (*eluttu*), which the researcher argues shows the

significance attached to numeracy. It is mentioned in *Pinkala Nikandu* (*an ancient book in Tamil*) that "*en*" and "*eluttu*" refer to "*Kanakku*"(*math*) (N. Subramanian, 1996, p. 157) as in Tamil, letters were used to denote numbers. It is argued that '*en*' refers to arithmetic and '*eluthu*' refers to algebra in which case, mathematics consisting of arithmetic and algebra is considered as the two eyes of a human being. In other words, the supremacy of mathematics has been acknowledged by the Tamils since ancient times.

4.2 Tinnai palli (Veranda schools)

In Thamizhakam, 'Tinnai' schools became popular in the 18th to 19th century. Every village or a cluster of nearby villages had a *Tinnai* school. Students paid the fees in cash and kind to the teacher; students also worked on the land of the teacher to pay the fee (Senthil Babu, 2007). The children were not divided into classes based on their ages, but according to their abilities to "learn language and mathematics" (ibid: p. 20). There was no standardized curriculum and the aim of this education was to prepare the children to be competent in language and numbers practised by the society.

Letters were used to represent 1 to 10, 100 and 1000. Using these 12 letters, they represented all numbers. One followed by 14 zeroes was named as "*Maha koti*". With the help of 'Ponnilakkam', we learn how numbers were denoted using 12 letters.



Ponnilakkam—elementary number primer for *Tinnai* schools (Courtesy French Institute of Pondicherry, Pondicherry). (Senthil Babu, 2007, p. 34)

They had special terms for each fraction. For example, $\frac{1}{320}$ is termed as *muntri*. The lowest fraction with a term is called *immi* (little) $\frac{1}{1075200}$ (ibid; p. 49). Students memorized the fraction table [eg., 4 *mahani* $(\frac{1}{16}) = 1$ *kal* $(\frac{1}{4})$]. However there was meaning in naming the terms such as $\frac{1}{8}$ has been termed as "*ari kal*" (half of quarter).

Similarly, $\frac{1}{32}$ is known as 'erandu kaaniye ari kaani'. Kaani$= \frac{1}{80}$.

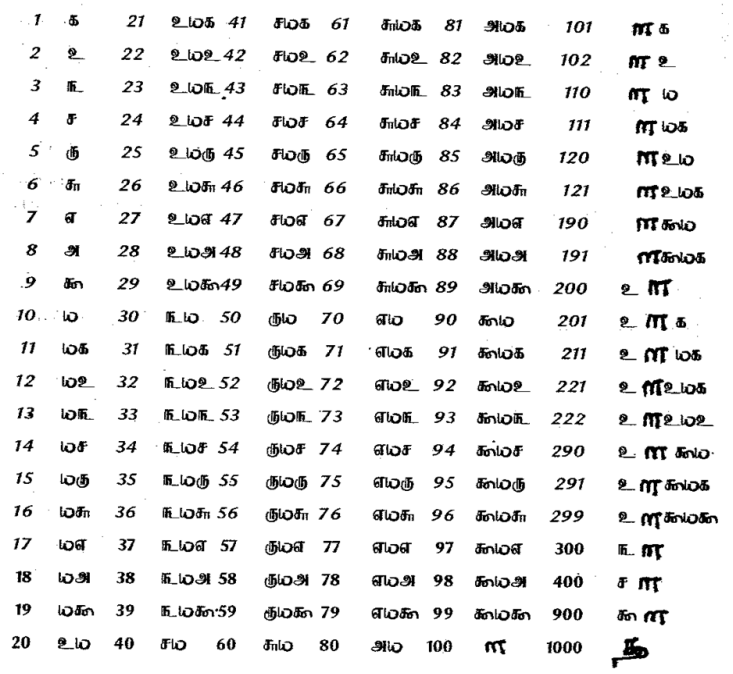
Erandu(twice) kaani$= 2 \times \frac{1}{80} = \frac{1}{40}$. Ari (half) kaani$= \frac{1}{2} \times \frac{1}{80} = \frac{1}{160}$.

Erandu kaaniye ari kaani$= \frac{1}{40} + \frac{1}{160} = \frac{5}{160} = \frac{1}{32}$ (ibid; p. 81)

According to a manuscript dated 1693, there were six types of measurement:

En alavu—numerals, *Kol alavu*—linear measurements, *Kal alavu*—measurements involving volume, *Tula alavu*—measurements in weighing, *Nal alavu*- measurement of time and *Teyva Atikaram*—dealing with celestials (astronomy) (Samuel, 2005b). Each of them had a conversion table which the students needed to master (for example, the smallest linear measurement was called one *seasame*. 8 *seasame* $=$

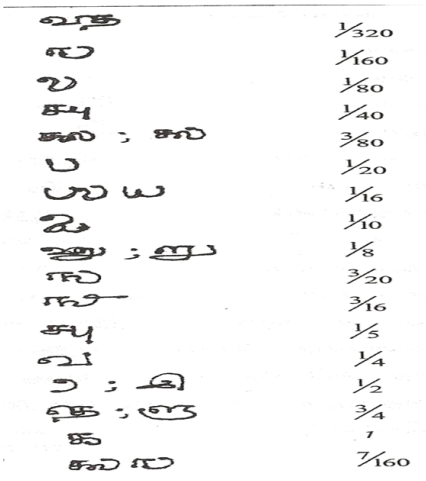
Like Tamil letters, Tamil numerals were also memorized.



(Samuel, 2005a, p. 292).

1 *paddy*, 8 *paddy* = 1 *finger*, 12 *fingers* = 1 *span*, 2 *spans* = 1 *foot*). All tables and conversions were memorized and recited. Memorization was the predominant pedagogy of learning. The *Tinnai* schools in *Thamizhakam* trained many pupils to memorize procedures and shortcuts from *Kanita Nul* to solve problems, which were in verse format to become accountants honing their mathematical skills and logical reasoning. As they needed to do long computations quickly and accurately in either agriculture, commerce or astrology, they were taught certain procedures, which they memorized. *Paun* has been is use for measuring the weight of gold since ancient time (which is eight grams of gold). They

Tamil letters, which were used to represent fractions, are listed below.



(Samuel, 2005a, p. 294).

had separate measurement conversions for gold.

31. மாவாகில் மஞ்சாடி மாகாணி பத்துமா
ஆமாகி முக்காணிக் காறுமா -- நேரே
குன்றிக் கரைமா பிறவுக்குக் காணியாய்
அரைக்காணிக் கோர்மாவாம் பொன்.

பொன் எண்ணின் தானம் அறிதல்.

ஒரு மாவுக்கு மஞ்சாடி என்றும், 1/16 க்கு 10 மா என்றும், 3/80 க்கு 6 மா என்றும், 1/40 க்கு குன்றி என்றும், 1/80 க்குப் பிளவு என்றும், 1/160 க்கு நெல் என்றும்; 1/320 க்கு அரை நெல் என்றும் சொல்லப்படும் என்றவாறு.

(Samuel, 2007, p. 65)

Translation:
1 Ma = 1/20 = I Manchadi Pon
1 Ma kani = 1/16 = 10 Ma Pon
1 Mukkani = 3/80 = 6 Ma Pon
1 Arama = 1/40 = 1 kunri Pon
1 Kani = 1/80 = 1 Pilavu Pon
1 Araikkani 1/160 = 1 Nel Pon
1 Muntiri 1/320 = 1/2 Nel Pon

Kannakkatikaram also has problems and solutions in verse format for farmers to find the area of land in the shape of an arrow (sector) and for government servants to calculate taxes, for goldsmiths and customers to find the purity of gold in ornaments. They also had formula to find the area of triangle and trapezium. The following verse from *Kanita Nul* informs us how to find the length of the yard-stick if the area is given.

குழியதி னாலே கோலறி குணர்ந்து
குழியின் சமனில் கோலடி பெருக்கி
இற்குழி சமனுக் கீய்ந்து பெற்ற
சொற்குழி கோலி னடியெனச் சொல்லுமே.

(Samuel, 2005a, p. 136)

Translation:
When measured by a 12 yard stick, the area is 100 *kuli* (unit for area). When the same area is measured by another stick of unknown length, the area becomes 25 *kuli*. Find the length of the yard stick.
The solution is given as follows:
$12\sqrt{100} = 12 \times 10 = 120$
Therefore the length of the second yard—stick= $120/5 = 24$.

Since ancient times, we had different names for multiples of ten, some of which are still in use in India such as 'Lakh' which is 100000 and 'Crore'(kodi in Tamil) which is 100 lakhs or 10000000 (10 millions). We also find verses explaining how to find the sum of numerals from 1 to 10 and sum of square numbers. The method to find the sum of squares from *Kanitha Nul* (an anicent mathematics

textbook in Tamil) is given below. This verse given below explains how $1^2 + 2^2 + 3^2 + 4^2 + 5^2 + 6^2 + 7^2 + 8^2 + 9^2 + 10^2$ can be computed.

கூறிய மட்டுங் குழிமா றினதொகை கூறவென்றால்
கூறிய தின்குழி யாற்கூறல் மாறியே கூறல்தள்ளி
மீறிய மூன்றொன்றி லேதான் தொகைதனை மேல்வைத்து
ஏறிய இலக்க மிதாமென வேகொல்லும் ஏந்திழையே.

(Samuel, 2005a, p. 101)

Translation:
Multipling 10^2 (which is 100) by 10 to get 1000.
By subtracting 10 from 1000, we get 990.
Dividing 990 by 3, we get 330.
Adding the sum of numerals from 1 to 10 (which is 55) to 330, we get 385, which will be the answer for the problem.

Samuel (2005a) translates another question from the manuscripts of *Kanita Nul*..

கால்முதல் கொண்டு பின்னெட் டுந்தொகை காணவென்றால்
சாலவு மெட்டுக்கும் எட்டுக்கா லென்றுஞ் சாற்றினதைச்
சீலமதா கக்குழி மாறின தன்னினஞ்சேர் திப்பிளவைக்
காலினி லீய்ந்திடக் கண்டிடுங் காணிக் கணக்கினையே.

(p. 91)

The above verse tells how to compute the sum of the series $\frac{1}{4} + \frac{1}{2} + \frac{3}{4} + \cdots + 8$.

Translation:
Divide 8 by quarter, which gives 32 (the number of terms).
Multiply 32 by 32 and add 32 and halve the result (which is $1024 + 32 = 1056 \div 2 = 528$.
Multiplying 528 by the quarter, the result is 132.

To conclude, memory has been used not as a mere strategy but as pedagogy to learn arithmetic in *Thamizhakam*. As agriculture and business were the main occupations, many short cuts for easier computation were taught. And the arithmetic they mastered was applicable to real life.

5 Problem-solving in ancient Thamizhakam

In mathematics teaching, students needed to memorize basic conversion (in measurement of length, weight etc.,), and tables involving numbers and fractions. Though arithmetic was the core of mathematics curriculum, problem solving was also a part of mathematics curriculum in ancient Thamizhakam (Senthil Babu, 2007). Several treatises on mathematics in Tamil are available in palm- leaf manuscript form. Palm leaves manuscripts that had been extensively used to learn arithmetical practice have been discovered and translated into formal Tamil and recently into English. There are 58 sums in verse format, 25 in prose style and another 25 sums known as prose style practice sums. The researcher cites

from Samuel (2005b) ancient problem solving questions both in verse and prose style, which was part of curriculum in ancient Thamizhakam.

Earlier, the problem was stated in verse format and passed on from generation to generation. Students needed to be good in language to understand the meaning of the problem. The chameleon question stated below was a popular one even after centuries. Even those who could not memorize the verse passed on the questions in prose format.

The problem stated below involves the conversion of measurements in lengths; however, it also tests the problem solving skill.

3. ஒணான் கணக்கு

(வெண்பா)

முப்பத்தி ரண்டு முழம்உள முட்பனையைத்
தப்பாமல் ஒந்தி தவழ்ந்தேறிச் – செப்பமுடன்
சாணேறி நான்கு விரற்கிழியும் என்பரே
நாணா தொருநாள் நகர்ந்து. (3)

கருக்கு நிறைந்த ஒரு பனைமரம். அது 32 முழம் உயரமுடையது. ஒரு நாளைக்கு சாண் அளவு ஏறி நான்கு விரலளவு இறங்கும் ஒரு ஒணான் எத்தனை நாளில் அம்மரத்தின் உச்சியை அடையும்?

(ibid: p. 54).

The translation of the popular 'Chameleon' problem is as follows:
A chameleon climbs up a palm tree of height 32 feet. It climbs up the tree a span length speed every day but slides down by a length of four fingers. How many days will it take to reach the top of the tree?

The problem solving questions in verse form involved many topics in Mathematics including rate, ratio and solving equations.

There were twenty—five questions written in prose style, which might have been written at a later period easing the burden on language. The twenty—five 'prose style practice style sums' are similar to 'prose style sums' involving "inductive reasoning" (ibid: p. 51). Some of these questions are more challenging than the verse style problems. These questions were passed on from generation to generation. The problem stated below involves solving equations with five variables, which could be reduced to two variables.

Translation:

Once there was a king in a town. One day a merchant presented a diamond to the king. The king wanted to know the price of the diamond. He had four ministers. He called his first minister and asked him the price of the diamond. He said the price of the diamond was equal to one third of his salary and the salaries of other three ministers. The king asked his second minister the cost of the diamond. He said that the cost of the diamond was equivalent to one fourth of his salary and the salaries of other ministers. Then the king called his third minister who said that the cost of the diamond was one fifth of his salary and the salaries of other ministers. The fourth minister told the king the cost of the diamond was equal to one sixth of his salary and the salaries of other three ministers. If the price

1. மாணிக்கத்தின் விலை காணல் கணக்கு

ஓர் ஊரில் ஓர் அரசன் இருந்தான். ஒரு நாள் ஒரு வியாபாரி ஒரு மாணிக்கத்தை அரசனுக்குப் பரிசாக அளித்தான். அந்த அரசனுக்கு 4 மந்திரிகள் இருந்தனர். அரசன் முதல் மந்திரியை அழைத்து மாணிக்கத்தின் விலை என்னவென்று கேட்டான். அதற்கு அந்த மந்திரி, தன் சம்பளத்தில் மூன்றில் ஒரு பங்கும், மற்ற மூன்று மந்திரிகளின் சம்பளமும் சேர்ந்தால் எவ்வளவு பணமோ அவ்வளவு என்றான். இரண்டாவது மந்திரியை அழைத்துக் கேட்டபோது, தன் சம்பளத்தில் நான்கில் ஒரு பங்கும், மற்ற மூன்று மந்திரிகளின் சம்பளமும் சேர்ந்தால் எவ்வளவு பணமோ அவ்வளவு என்றான். மூன்றாவது மந்திரியை அழைத்துக் கேட்டபோது, தன் சம்பளத்தில் ஐந்தில் ஒரு பங்கும் மற்ற மூன்று மந்திரிகளின் சம்பளமும் சேர்ந்தால் எவ்வளவு பணமோ அவ்வளவு என்றான். நான்காவது மந்திரியை அழைத்துக் கேட்ட போது, தன் சம்பளத்தில் ஆறில் ஒரு பங்கும் மற்ற மூன்று மந்திரிகளின் சம்பளமும் சேர்ந்தால் எவ்வளவு பணமோ அவ்வளவு என்றான். இந்த நான்கு மந்திரிகள் சொன்ன விலையும் ஒரே விலையாக இருந்தது என்றால் மாணிக்கத்தின் விலை என்ன? மந்திரிகள் ஒவ்வொருவரின் சம்பளம் எவ்வளவு?

(ibid: p. 93).

quoted by all of them is the same, find the cost of the price of the diamond. What was the salary of each one minister?

Though there was a strong emphasis on memorization, the curriculum also developed problem-solving skills and included practical application questions. The problem given below gives a typical example testing intuitive reasoning.

5. சேவகன் சம்பளக் கணக்கு

ஓர் அரசனிடத்தில் ஒருவன் சேவகனாக வேலைக்குச் சேர்ந்தான். அவனுக்கு ஒரு நாளைக்கு ஒரு வராகன் சம்பளம். அவன் 30 நாட்களுக்கு அரசன் இடத்தில் வேலை செய்வதாக ஒப்பந்தம் செய்து கொண்டான். சேவகன் எப்பொழுது வேலையில் இருந்து நின்றாலும் அத்தனை நாட்களுக்குச் சம்பளம் கொடுப்பதற்கு ஏற்றவாறு 30 வராகன் எடையில் அரசன் 5 மோதிரங்களைச் செய்து விரல்களில் அணிந்து கொண்டான். அந்த 5 மோதிரங்கள் ஒவ்வொன்றும் எத்தனை வராகன் எடை கொண்டவை?

(ibid: p. 96)

Translation:
A king had made five rings of different weights in such a way that whenever he dismissed his servant, he could pay his salary exactly as ring(s). If the salary of the servant each day is one '*poun*' (8 g) gold, what are the weights of the rings (in terms of *pouns*) of the king?

According to Samuel (2005a), though memorization of conversion tables and short cuts from *Kanita Nul* helped merchants to perform computation effectively, to make 'school mathematics useful to real life' the problem—solving questions in real life situations might have been written. These kind of questions kindled students' interest in mathematics. They also complemented the 'memory driven mathematics curriculum', enhancing students' logical thinking.

6 Snapshot of an Indian mathematics classroom in 21st century

The researcher observed and video recorded thirteen consecutive mathematics lessons in Chennai, the capital of Tamil Nadu in 2006. While the teaching practices of a teacher in 8th grade mathematics classroom are analyzed, the teacher under study was found practicing the ancient pedagogies such as the use of memorization, oral repetition, and questioning. She asked every student questions following a rigid pattern and helped the students to verbalize mathematical arguments. In her interview, the teacher acknowledged the use of memorization, oral repetition and questioning as she claimed they have pedagogical values. In every lesson, she asked her students to recall different formulae that they have learnt. According to the teacher, memorization of basic mathematical facts and formulae are essential for mastering fundamental mathematics. She asked the same questions to many students, as she believed in use of oral repetition to enhance learning. She even made a student to repeat five times the formula, which he could not recall. While classrooms in some other cultures downplay the use of oral repetition in learning and some modern learning theories attach negative connotation to ancient pedagogies as old fashioned, in the classroom under study, oral repetition played a positive role in aiding memorization, developing students' understanding and helping learners master mathematical language and to communicate mathematics. According to an Indian educationalist, "oral repetition is another approach to involve the slow learner to the main stream and it would be a misinterpretation to consider this oral tradition as one lacking individual outcome" (Personal communication, D. Subramaniam, August 2010).

7 Conclusion

On referring to literature, the researcher concludes that the pedagogies that have been in use in India since ancient times are learning by listening, teacher questioning, memorization and oral repetition. The researcher identifies these pedagogies even in a 21st century Indian mathematics classroom as these pedagogies have been transmitted for generations. Both teacher and students in the observed classroom reported valuing these pedagogies. The researcher classifies them as culture influenced pedagogies, as they are learned behaviours, being transmitted for generations. The researcher also refers to mathematics curriculum to illustrate how mathematics was taught and learnt in ancient southern part of India and the significance attached to memorization by citing the ancient arithmetic book called *Kanita Nul*. She also cites some of the problem solving questions which were transmitted for generations orally and which were also part of the curriculum even in 18th to 19th centuries in Thamizhakam, the ancient South India.

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