THE INDIA FORUM
A JOURNAL-MAGAZINE ON CONTEMPORARY ISSUES

May 20, 2025

What has Culture to do with Mathematics?

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Multiple forms of mathematical knowledge exist among different communities, which draw from specific cultural contexts and are utilised for local needs.

We live in a world that is perceived to be governed as well as shaped by mathematics. It is often said that mathematics is the language of nature or that the laws of nature are coded in mathematics. That we are able to use our understanding of nature to control it only gives credence to the belief that "the book of nature is written in the language of mathematics," a quote attributed to Galileo Galilei.

The metaphor of language and codes would imply some subjectivity to mathematics. Mathematicians exposed to the foundations of (modern, Western) mathematics, cannot but concede to the fact that mathematical truths are not absolute: they are subject to a chosen axiomatic framework and there is no escape from making a choice of an axiomatic framework, somewhat akin to a paradigm choice made in science. For all practical purposes, a practising mathematician shares the popular wisdom that mathematical truths are absolute, timeless and out there waiting for a mathematician to discover them. Perceived as esoteric, the pursuit of which for a mathematician is synonymous with the pursuit of truth, and is timeless and of mystical beauty, mathematics then has all the ingredients that places it beyond the reach of all. Moreover, it also allows for priority battles about who discovered which mathematical truth first and contributes to boosting fragile national pride.

Indeed, the National Education Policy 2020 states "a rootedness and pride in India, and its rich, diverse, ancient and modern culture and knowledge systems and traditions" as one of the foundational principles that will guide the education system and says ancient India has made seminal contributions to several domains of knowledge including mathematics.

Reckoning with culture

Interestingly, one of the domains from which significant challenges to the notion of mathematics and mathematical truth as eternal and existing ‘out there’, have emerged is mathematics education. Mathematics, a compulsory school subject, has the dubious reputation of being a gate keeper and it goes without saying that among those who fail in mathematics in secondary education, a large percentage belong to the socio-cultural and economic margins.

> In the name of celebrating ethnomathematical knowledge and incorporating it in school education, we may move towards a curriculum where learners from socio-economic margins may be deprived of an opportunity to learn the kind of mathematics that leads to gainful employment...

By the 1960s, mathematics education researchers (largely from outside India), in their attempt to situate learning of mathematics in contexts meaningful to the learners, took note of different forms of mathematical knowledge that existed outside what was taught in schools. These included ‘indigenous mathematics’,referring to mathematical practices of certain indigenous communities; ‘informal mathematics’, referring to everyday mathematics which is different from the formal mathematics taught in school; ‘oral mathematics’, prevalent among all societies and passed on orally from one generation to the next; ‘street mathematics’ referring to mathematical knowledge of street vendors, and so on. The education researchers John Gay and Michael Cole (1967) found that unschooled Kpelle traders in Liberia estimate quantities of rice better than an educated American. Terezinha Nunes and others found that young street vendors could perform complex computations orally, even as they failed miserably in carrying out the same computations in the written form using the algorithms taught in school.

These findings along with notions such as situated cognition (as against the notion of individual cognitive development aided by education) that emerged in educational psychology, foregrounded the role of culture in the teaching and learning of mathematics.

Another motivation for researching mathematics outside the modern Western canon came from the demand for culturally focused courses from Black students, as part of the affirmative action movement in the US in the 1960s. Claudia Zaslavsky studied and

documented mathematical knowledge such as complex geometry and patterns embedded in the artefacts in African culture. (Zaslavsky was a mathematics teacher in the US who realised the importance of incorporating mathematics from African culture in the mathematics curriculum for her students to have pride in their cultural heritage.) The works of Zaslavsky and Paulus Gerdes brought to light rich mathematical knowledge found in African countries. In South America, Marcia Ascher and Robert Ascher, a mathematician and an anthropologist, respectively, noted how the Incas had a sophisticated knowledge of mathematics and used knotted strings called quipu to record numbers as well as carry out computations.

For many of us in India, some of these forms of mathematics may seem very commonplace. Till supermarkets and pocket calculators arrived, we computed orally at the grocery shop and vegetable market. In fact, we still see vendors at the vegetable and fish markets, as well as those engaged in local commercial activities do oral computations, though they may not have had formal education. We also find symmetry, geometrical figures, and patterns in artefacts.

Seen from our experience of school and high mathematics these forms of mathematics seem elementary, and we never thought we need to treat these forms of mathematics as different from the mathematics we learn from school. If we should treat these forms of mathematics as different from the mathematics we learn in school and college, what could be a justification for doing so?

Emergence of ethnomathematics

Reducing mathematics to simply the product – mathematical truths, results of computations and so on – and leaving out the context in which it emerged, enables that form of mathematics that has the power at a certain point of time to validate or reject and subsume others as inferior versions of it.

At present this power lies with what is referred to as academic mathematics, namely the mathematics pursued in universities across the world today. This form of mathematics, seen as Eurocentric and White supremacist, displaced all other dominant forms of mathematics across the world and situated itself at the centre. For example, ancient Indian traditions of classical mathematics – the Bhatta, Bhaskara tradition of mathematics – are not alive anymore. It is doubtful that Chinese and other dominant traditions in mathematics managed to survive and coexist alongside academic mathematics.

> Multiple forms of mathematical knowledge created by different cultural groups to meet different ends, calling for varying degrees of rigour are brought into existence, and they coexist at any point of time.

The term ethnomathematics was coined by the Brazilian mathematician and mathematics educator Ubiratan D' Ambrosio in the late 1970s. Though the term is often used to refer to mathematical knowledge of ethnic groups, D' Ambrosio uses the term in a broader sense. He says "in contrast to the academic mathematics, we will call ethnomathematics, the mathematics which is practised among identifiable cultural groups, such as national-tribal societies, labour groups, children of a certain age bracket, professional classes, and so on. Ethno-means a culturally identified group sharing jargons, code, knowledge and practices, language, symbols, myths and specific ways of reasoning and inferring." This includes practices such as ciphering and counting, measuring, classifying, ordering, inferring, modelling, and so on under ethnomathematical practices.

This definition of ethnomathematics certainly includes forms of mathematical knowledge found in tribal communities. But it also includes mathematical knowledge produced by different communities of practitioners within modern academia. For example, he says, "we may go even further in the concept of ethnomathematics to include much of the mathematics that is currently practiced by engineers, mainly calculus which does not respond to the concept of rigor and formalism developed in academic courses of calculus." Though in the very formulation of ethnomathematics D'Ambrosio excludes academic mathematics, we need to acknowledge the fact that academic mathematics too is practised among the culturally identified group of professional mathematicians who share "jargons, code, knowledge and practices, language, symbols, myths and specific ways of reasoning and inferring."

Over the last four decades a significant amount of research in ethnomathematics has been carried out by scholars from Brazil and other parts of the world. Ethnomathematical knowledge may sometimes engage with a knowledge form that is not alive. But often it focuses on a form of knowledge that is in practice because most the research in the domain is carried out by mathematics education researchers who seek to build a bridge between school mathematics and the mathematical knowledge that is part of the learners' cultural background. As cultures keep changing in response to the larger socioeconomic changes, ethnomathematical knowledge forms too keeps changing.

Ethnomathematical knowledge is not always utilitarian in nature. Angolan sand drawings, which are similar to kolams and rangoli in India, patterns in artifacts such as colourful patterns on the baskets, and geometrical designs used in weaving are some instances in which ethnomathematical knowledge is used for needs that transcend the immediate. Games and puzzles involving mathematics are found in almost all cultures.

Ethnomathematics places a strong emphasis on the context in which the mathematical knowledge is produced, and the process evolved by the practitioners. This is very powerful because it draws attention to the fact that multiple forms of mathematical knowledge exist among different communities of people – and these forms of mathematical knowledge were produced by the communities that employ them. Epistemologically, academic mathematics and different ethnomathematical forms may have very little in common.

This essentially means that mathematics is not unique as is often claimed. Multiple forms of mathematical knowledge created by different cultural groups to meet different ends and calling for varying degrees of rigour, are brought into existence, and they coexist at any point of time. In the context of mathematics education, this plurality demands we see the learner as potentially immersed in and bringing to the classroom some form of ethnomathematical knowledge. As it happened in the case of Brazillian street vendors who quickly carried out complex arithmetical computations orally but could not do the same with paper and pencil, using the algorithm taught in school, it forces the educators to redesign the curriculum in such a way that there in some scope for the learner to draw from the ethnomathematical knowledge one already has, to answer questions posed in the school.

The Indian context

One of the earliest works in India to study mathematical knowledge that learners acquire outside school was a doctoral thesis by Farida Khan in the 1990s. She focused on newspaper vendors and paan sellers in New Delhi and showed how the young vendors learnt from each other to orally compute the cost of what they sold and the balance they need to return and so on, while they perform poorly in school mathematics.

> Can we say Vedic mathematics is a form of ethnomathematics? The answer is no.

Swapna Mukhopadhyay studied the mathematics embedded in the work of boat builders in West Bengal. We have a few studies that look at the mathematical knowledge of carpetmakers, masons, vegetable vendors, bus conductors, and so on. There is a wealth of knowledge about mathematics embedded in the practice of communities engaged in traditional occupations that is waiting to be discovered. Given that traditional occupation in India was caste-based, such studies would also tell us if and how caste figures in the production and exchange of mathematical knowledge.

The history of mathematics has received a lot of attention in the recent times from scholars in India and abroad. Most of the historical studies focus on the classical traditions, with contributions in Sanskrit from scholars such as Aryabhatta, Bhaskara and others, and not all of these have something to do with Vedic religion of the time. This tradition, largely restricted to Kerala in the later period, was alive till the 19th century. The classical traditions also include contributions in Prakrit and Pali from Buddhist and Jain scholars and later the contributions from the Islamic tradition. It is pertinent note here that classical geometry in India was not axiomatic, while its counterpart Greek geometry is not only axiomatic but it became a model for academic mathematics.

D. Senthil Babu, a historian, traces a very different history of mathematics. He focuses on the *Kanakkathikaram* tradition in Tamil Nadu and traces a history of mathematics embedded in practice and the systematic ways in which it was transmitted. In his own words, “In the *Kanakkathikaram* texts, the producers, workers, and administrative professionals represented themselves thought their work and skill.” Interestingly, the texts do not use the Indo-Arabic decimal place value-based numeration system. Different kinds of mathematical tables were in use and the pedagogic approach emphasised the use of “reconstructive memory.”

Mathematics education researchers in India have been ambivalent towards using the term ‘ethnomathematics’. Their discomfort arises from the fear that in the name of celebrating ethnomathematical knowledge and incorporating it in school education, we may move towards differentiated mathematics curriculum where learners from socio-economic margins may be deprived of an opportunity to learn the kind of mathematics that leads to gainful employment in industry and academia. Moreover, communities engaged in traditional occupations are desperately trying to access higher education and find employment in the modern employment sector by improving their economic status and erasing, at least partially, their caste identity. While these concerns are valid, these should not deter us from studying and documenting different forms of ethnomathematical knowledge.

A cautionary note

We are living at a time when premier institutions have centres specialising in ancient Indian knowledge systems. A quick google search will give us a list of universities and colleges in India where Vedic mathematics is offered as a course. It is also offered to school children as part of the school curriculum or as an additional course outside school.

> Premodern Indian mathematics can be considered as a form of ethnomathematics, but it has contributions from Buddhist, Jain, and Islamic traditions and hence cannot be called Vedic mathematics.

Can we say Vedic mathematics is a form of ethnomathematics? The answer is no.

The term 'Vedic mathematics' was coined as the title of a book (consisting of 16 computational shortcuts) written by Shankaracharya Barati Krishna Tirtha in the 20th century. The contents of the book have nothing to do with ancient Indian mathematics, as well argued by S.G. Dani (1993), a mathematician from TIFR Mumbai, nor is it a form of mathematical knowledge produced by a community. In 2024, at the 15th International Congress of Mathematics Education, a workshop on Vedic mathematics attempted to imply that the term Vedic mathematics refers to all ancient Indian mathematics and not just the contents of the above book. Pre-modern Indian mathematics can be considered as a form of ethnomathematics, but it has contributions from Buddhist, Jain, and Islamic traditions and hence cannot be called Vedic mathematics. It must also be noted that while mathematical computations may be used in astrology, it cannot be considered as ethnomathematics and taught in schools because, astrology is not a valid form of knowledge that can be tested empirically or defended logically.

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