
Global Certificate Course in Ethnomathematics Instruction

Cultural Number Systems

Abacus (Chinese counting frame)

Related terms: calculating board, counting beads

The abacus is a portable wooden frame with rows of beads that represent units, tens, hundreds, and higher orders. Users manipulate beads to perform addition, subtraction, multiplication, and division by physically moving them, reinforcing place-value concepts. In classroom settings the abacus supports visual-kinesthetic learners and bridges traditional Asian arithmetic with modern curricula. Challenges include aligning bead movements with abstract symbolic notation and ensuring students transfer procedural fluency to paper-and-pencil calculations.

Aksar (Arabic-Indic numeral forms)

Related terms: Eastern Arabic numerals, script numerals

Aksar refers to the set of numerals used throughout the Arab world that differ in shape from Western Arabic numerals (0-9). These glyphs appear in handwritten and printed Arabic texts, influencing how learners recognize and write numbers. Instructional activities compare Aksar to Western forms, fostering cross-cultural numeral literacy. Difficulties arise when learners encounter mixed scripts in digital media, requiring explicit teaching of numeral conversion and typographic awareness.

Alphanumeric system

Related terms: letter-number codes, mixed notation

An alphanumeric system combines letters and numbers to encode information, such as "A1" for a grid coordinate or "B-12" for a bus route. In ethnomathematics, alphanumeric codes illustrate how cultures embed quantitative data within linguistic symbols, supporting tasks like map reading or inventory tracking. Practical applications include classroom games that map letter-number combos to real-world contexts. Pedagogical challenges involve ensuring students understand the dual symbolic meaning and avoid confusion between numeric value and categorical label.

Base

Related terms: radix, numeral foundation

Base denotes the number of distinct digits a numeral system employs before requiring a new positional column. The most familiar base is ten, but many cultures historically used bases such as twelve, twenty, or sixty. Understanding base concepts enables learners to grasp why "10" in base-12 represents twelve in decimal. Classroom activities might involve converting numbers between bases to reveal structural similarities. The main challenge is preventing cognitive overload when students simultaneously manage multiple bases.

Base-12 (duodecimal)

Related terms: dozenal, twelve-based counting

The duodecimal system uses twelve as its radix, employing digits 0-9 plus two additional symbols (often "A"

and “B”) for ten and eleven. Cultures such as the ancient Egyptians and the contemporary Dozenal Society value base-12 for its divisibility by 2, 3, 4, and 6. Instructional examples include dividing a dozen eggs without remainder, highlighting practical advantages. Learners may struggle with unfamiliar symbols and the need to reinterpret familiar fractions (e.g., $1/3$ becomes 0.4 in duodecimal).

Base-20 (vigesimal)

Related terms: score-based, Mayan, French counting

Vigesimal systems count in twenties, reflecting a cultural emphasis on the human hand plus fingers of both feet. The Mayan civilization, some African societies, and French (e.g., “quatre-vingt”) exhibit vigesimal traits. Classroom tasks can involve counting objects in groups of twenty and translating vigesimal numerals to decimal. A common difficulty is the irregular French teens (e.g., “soixante-dix”) that blend base-20 with base-10, demanding careful linguistic analysis.

Base-60 (sexagesimal)

Related terms: Babylonian, time division, angular measurement

The sexagesimal system, with sixty as its radix, originated in ancient Mesopotamia and persists in modern time (60 seconds = 1 minute) and angle ($360^\circ = 6 \times 60$). Teaching the sexagesimal system connects historical mathematics to everyday life, such as reading clocks or using a protractor. Students practice converting between decimal and sexagesimal fractions, reinforcing place value. Challenges include the non-intuitive nature of sixty-based fractions and the need to interpret ancient cuneiform numerals accurately.

Binary

Related terms: base-2, digital logic, on/off coding

Binary notation employs only two symbols—0 and 1—to represent all numbers, mirroring the on/off states of electronic circuits. In ethnomathematics, binary highlights how modern technological cultures encode information, contrasting with traditional multi-digit bases. Classroom demonstrations using LED lights or simple computer simulations illustrate binary counting. Learners often encounter difficulty grasping the exponential growth of place values (e.g., $2^3 = 8$) and must practice repeated halving and doubling to internalize the system.

Cuneiform numerals

Related terms: Mesopotamian script, wedge-shaped symbols

Cuneiform numerals are a set of wedge-shaped marks impressed on clay tablets to denote numbers in base-60 and later base-10. They combine vertical and horizontal wedges to indicate units, tens, and larger multiples. Translating cuneiform numerals offers students a tangible link to ancient accounting and astronomy. Practical activities include reproducing wedge marks with modeling clay and converting recorded quantities to modern numerals. The primary challenge lies in deciphering the positional context, as early cuneiform lacked a true zero.

Decimal

Related terms: base-10, ten-based system

Decimal is the globally dominant base-10 numeral system, using ten distinct digits (0-9) and a positional value that increases by powers of ten. Its ubiquity makes it the default framework for most curricula, yet ethnomathematics encourages comparison with non-decimal traditions. Instruction may involve exploring

why ten became prevalent (e.g., finger counting) and how decimal fractions differ from those in other bases. Students sometimes conflate decimal place value with fractional concepts, necessitating explicit clarification.

Decimal fraction

Related terms: tenths, hundredths, fractional notation

A decimal fraction expresses a part of a whole using a decimal point followed by digits representing tenths, hundredths, etc. In many cultures, decimal fractions coexist with vulgar fractions (e.g., $\frac{1}{2}$) and with base-12 or base-20 fractions. Classroom examples include measuring liquid volumes in liters (e.g., 0.75 L) and converting to fractions ($\frac{3}{4}$). Challenges arise when learners must switch between decimal and non-decimal fraction representations, especially when cultural practices favor mixed-base units.

Digits

Related terms: numerals, symbols, counting units

Digits are the individual symbols used within a numeral system to represent values. Their meaning depends on the base and positional context. For instance, the digit "3" in base-5 signifies three units, whereas in base-12 it still represents three units but occupies a different place value. Activities that isolate digits—such as rearranging cards bearing numerals—help students see the modular nature of numbers. A common obstacle is the tendency to treat digits as fixed values independent of their position.

Dotted notation

Related terms: tally marks, dot counting, unary representation

Dotted notation uses a series of dots or simple marks to indicate quantity, often in groups of five (four vertical dots topped by a diagonal). This unary method appears in many indigenous counting practices and in early school tallies. Teachers can employ dotted notation to introduce addition and subtraction before formal place-value systems, reinforcing concrete counting. The limitation is scalability; representing large numbers becomes unwieldy, and learners must transition to more efficient positional systems.

Ethnomathematics

Related terms: cultural mathematics, math anthropology

Ethnomathematics studies how mathematical ideas are embedded in cultural practices, languages, and artifacts. It emphasizes that number concepts, measurement, and spatial reasoning vary across societies. In a global certificate course, ethnomathematics frames the exploration of cultural number systems, encouraging comparative analysis and respectful integration of diverse mathematical traditions. Implementation challenges include balancing depth of cultural insight with curricular standards and avoiding superficial tokenism.

Fibonacci sequence (cultural contexts)

Related terms: rabbit problem, spirals, growth patterns

The Fibonacci sequence (1, 1, 2, 3, 5, 8, ...) appears in various cultural motifs, such as the arrangement of seeds in a sunflower or the design of traditional African drums. Teaching the sequence through cultural examples illustrates how mathematical patterns arise organically in art, architecture, and nature. Students might measure spiral angles in a nautilus shell and relate them to successive ratios. Difficulties include abstracting the recursive rule from concrete visual patterns and recognizing the sequence beyond Western mathematical history.

Glyphic numerals

Related terms: symbolic numbers, pictographic notation

Glyphic numerals are visual symbols that directly represent quantities, often derived from objects (e.g., a stylized corn cob for "grain"). Many indigenous societies use glyphs on pottery, textiles, or rock art to record trade amounts or ceremonial counts. Classroom projects can involve designing glyphic numerals for a classroom economy, fostering creativity and cultural appreciation. A challenge is ensuring that glyphs convey precise numeric values without a standardized positional framework, which can lead to ambiguity.

Hieroglyphic numerals

Related terms: Egyptian symbols, pharaonic counting

Ancient Egyptian hieroglyphic numerals employed distinct symbols for 1, 10, 100, 1 000, 10 000, 100 000, and 1 000 000, arranged in descending order without a place-value system. For example, the number 2 345 would be written as two "thousands," three "hundreds," four "tens," and five "units." Students can reconstruct hieroglyphic numbers using magnetic tiles, gaining insight into additive versus positional notation. The primary pedagogical obstacle is helping learners internalize the lack of a zero and the additive nature of the system.

Inca quipu

Related terms: khipu, knot recording, Andean data

The quipu is a knotted string device used by the Inca Empire to encode numerical information, such as census data or tribute amounts. Different knot types (single, long, figure-eight) and cord colors represent units, tens, hundreds, and higher orders, often employing a base-10 structure. In classroom settings, students create miniature quipus to record class scores, linking tactile experience with abstract numeracy. Interpreting authentic quipus remains a scholarly challenge, as the exact encoding rules are not fully deciphered.

K'iche' numeral system

Related terms: Mayan descendant, vigesimal tradition

The K'iche' Maya language preserves a vigesimal counting system where numbers above twenty are expressed as "one score plus" a remainder (e.g., 23 = "one score three"). Numerals are spoken and written using a combination of base-20 units and decimal sub-units. Classroom activities might involve translating K'iche' numerals to decimal and exploring cultural contexts such as market transactions. Learners often find the mixed base-20/10 phrasing confusing, requiring explicit teaching of hierarchical grouping.

Lattice counting

Related terms: grid enumeration, array method

Lattice counting uses a rectangular grid of squares to represent multiplication or area, allowing learners to count rows and columns systematically. Many African societies employ woven mats or bead arrays that function as physical lattices for trade calculations. Students can draw lattice diagrams to visualize the product of two numbers, reinforcing the distributive property. The difficulty lies in transitioning from concrete lattice objects to abstract algebraic notation, especially when cultural practices lack a written numeral component.

Maya Long Count

Related terms: calendar cycles, baktun, k'in

The Maya Long Count records elapsed days using a hierarchical base-20 and base-18 structure:

1 k'in = 1 day, 1 winal = 20 k'in, 1 tun = 18 winal (≈ 360 days), 1 k'atun = 20 tun, and 1 baktun = 20 k'atun. This mixed base system reflects astronomical cycles and ceremonial calendars. Classroom exercises may involve converting a Long Count date to a Gregorian calendar year, illustrating the interplay of mathematics and cultural timekeeping. Learners must navigate the irregular base-18 step, which can cause calculation errors.

Mayan numeral

Related terms: dot-bar notation, vigesimal

Mayan numerals consist of dots (value 1) and bars (value 5) arranged vertically to represent numbers from 0 to 19; a shell glyph signifies zero. Numbers are written in a vertical positional system, with the lowest order at the bottom. For example, the decimal number 33 appears as one bar (5) plus eight dots (8) in the lower position, and a single dot (1) in the next higher position ($5 \times 20 + 13$). Students can build Mayan numerals with clay or paper to internalize base-20 counting. A common hurdle is remembering the orientation (bottom-up) and the role of the zero shell.

Numeral base

Related terms: radix, counting foundation

A numeral base specifies the quantity of unique symbols used before a new positional column is introduced. Bases such as 2, 5, 10, 12, 20, and 60 each generate distinct place-value tables. Understanding numeral bases enables learners to see why "100" in base-5 equals twenty-five in decimal. Instruction can include base-conversion puzzles that reveal structural similarities across cultures. Students may experience cognitive overload when simultaneously handling multiple bases, necessitating scaffolded practice.

Numeral hierarchy

Related terms: place value, magnitude ordering

Numeral hierarchy refers to the ordered arrangement of digit positions from least to most significant, establishing magnitude relationships (units, tens, hundreds, etc.). In non-positional systems like Egyptian hieroglyphs, hierarchy is expressed by arrangement rather than place value. Demonstrating hierarchical ordering through stacked blocks helps learners visualize how larger values dominate smaller ones. The challenge is that some cultural systems lack a clear hierarchy, requiring learners to interpret additive groupings rather than positional scaling.

Numeral system

Related terms: number notation, counting framework

A numeral system is a set of symbols and rules for representing numbers, encompassing base, digit repertoire, and positional or additive conventions. Examples include decimal, Roman, Mayan, and quipu systems. Comparative study of numeral systems reveals cultural priorities such as trade, astronomy, or ritual. Classroom projects may involve creating a hybrid numeral system that blends features from two cultures, fostering creative synthesis. Difficulties arise when students try to apply familiar decimal rules to systems that lack zero or positional value.

Numeracy

Related terms: mathematical literacy, quantitative competence

Numeracy denotes the ability to understand and manipulate numbers, measurements, and basic mathematical concepts in everyday contexts. Ethnomathematical approaches broaden numeracy by incorporating culturally relevant counting practices, such as using tally sticks or market bargaining. Practical applications include budgeting for a community event using local numeral forms. Teachers must balance cultural authenticity with the development of transferable mathematical skills, ensuring learners can navigate both indigenous and global numeric conventions.

Oral numeracy

Related terms: spoken counting, verbal arithmetic

Oral numeracy involves expressing quantities, operations, and relationships through spoken language rather than written symbols. Many societies rely on oral traditions for trade, storytelling, and ritual counting, using counting words, rhymes, or chants. Classroom activities like “number songs” draw on oral numeracy to strengthen mental calculation and memory. A limitation is that oral systems may lack standardized notation, making it harder to document and assess proficiency across diverse linguistic groups.

Place value

Related terms: positional value, digit weight

Place value assigns each digit a weight based on its position within a numeral, typically powers of the base. For example, in decimal the digit “3” in the hundreds place represents three hundred (3×10^2). Many cultural systems, such as Mayan and Babylonian, employ place value, while others use additive grouping. Demonstrations using base-ten blocks or digital simulations clarify the concept. Learners often conflate the symbol’s intrinsic value with its positional weight, leading to misconceptions that must be explicitly addressed.

Positional notation

Related terms: place-value system, digit positioning

Positional notation is a numeral representation where the value of a digit depends on its location relative to other digits, as opposed to additive notation where symbols are simply summed. Systems like decimal, binary, and Mayan employ positional notation, whereas Roman numerals are largely additive. Classroom experiments can involve rearranging digits to observe value changes, reinforcing positional dependence. The primary challenge is helping students transition from additive cultural scripts to positional thinking, especially when their native language uses non-positional numerals.

Quipu

Related terms: khipu, knot recording, Andean mathematics

Quipu (also spelled khipu) is a cord-based recording device featuring knots of varying types and colors to encode numerical and possibly narrative data. Primary knots represent units, tens, and hundreds, while subsidiary cords convey higher orders. Modern educators replicate quipu to teach place value and base-10 concepts through a tactile medium. Interpreting authentic quipu remains speculative; some scholars argue for non-numerical information such as storytelling. Students may find the lack of a written script confusing, requiring careful scaffolding to link knot patterns to numeric values.

Roman numerals

Related terms: Latin notation, additive/subtractive system

Roman numerals use letters I, V, X, L, C, D, and M to represent values, combining additive (II = 2) and subtractive (IV = 4) principles. Though not positional, the system reflects cultural emphasis on monumental inscription and trade accounting. Classroom tasks include converting dates to Roman numerals and exploring the historical transition to Arabic numerals. A common difficulty is mastering the subtractive rule and remembering the limited range of symbols, which can hinder rapid calculation.

Sanskrit numerals

Related terms: Devanagari digits, Indian counting

Sanskrit numerals, written in the Devanagari script, represent the decimal system with distinct glyphs for 0-9, including the earliest known use of zero as a placeholder. They appear in ancient Indian mathematical treatises and astronomical tables. Teaching Sanskrit numerals provides insight into the origin of modern decimal notation and cultural diffusion. Students can practice writing numbers in Devanagari and compare them to Western forms. The main obstacle is unfamiliar character shapes, which may require dedicated handwriting practice.

Subtraction (cultural methods)

Related terms: borrowing, borrowing-free techniques

Various cultures develop unique subtraction strategies, such as the Inca's use of complementary knots on quipu or the African "counting backwards" method that avoids borrowing. Demonstrating these techniques highlights the diversity of algorithmic thinking. Practical applications include solving word problems using culturally resonant methods before introducing the standard borrowing algorithm. Learners may experience conflict when multiple subtraction approaches coexist, necessitating explicit discussion of each method's validity and situational efficiency.

Tally marks

Related terms: dot counting, unary tally

Tally marks are a simple unary system where each stroke represents a single unit, often grouped in fives for readability. This method appears worldwide, from ancient tally sticks to modern receipt receipts. Classroom use of tally marks supports early addition and subtraction, reinforcing one-to-one correspondence. Limitations include difficulty representing large quantities and the absence of place value, which can impede transition to more complex numeral systems.

Vedic mathematics

Related terms: ancient Indian techniques, sutra methods

Vedic mathematics comprises a collection of mental calculation shortcuts derived from ancient Indian sutras, covering multiplication, division, and algebraic manipulation. Though not a numeral system per se, its techniques illustrate culturally specific problem-solving strategies. Instructors can integrate Vedic methods to accelerate arithmetic fluency while acknowledging their historical context. Challenges involve ensuring students understand the underlying principles rather than memorizing tricks, and aligning Vedic shortcuts with standard curricular expectations.