

Pakistan

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Introduction

Overview of Education System

Pakistan is the fifth most populous country in the world. The population explosion and democratic aspirations of the people have put the present education system under great strain. Education planners and administrators are striving to cope with these challenges. The 18th amendment of the Pakistani Constitution transfers the responsibility for education from the federal government to states and provinces.¹ National education policy enacted in 2017 has been designed according to this structure.^{2,3}

Education is almost completely decentralized, with province and area education departments responsible for the education system, from planning to implementation. The federal government has a limited role. The Ministry of Federal Education and Professional Training is facilitating and coordinating among the province and area education departments to maintain coherence in education policies. In this regard, after a gap of 10 years, a national curriculum is in development in consultation with provincial and area education departments.

Pakistan's education system is distributed into four level of educations:

- Elementary education
- Secondary education
- Higher secondary education
- Tertiary education

In Pakistan, about 60 percent of students attend public schools, while the remaining 40 percent of students attend private schools.⁴ Public school students mostly come from a low socioeconomic background while private school students mostly have middle- and upper-class backgrounds. Public sector institutions are required to teach the national curriculum. Private sector institutions may teach different types of curriculum, including the Oxford, Cambridge, and Singapore curricula.

Use and Impact of TIMSS

Pakistan participated in TIMSS for the first time in 2019 at Grade 4. Results will be used to shape the following areas:

- Policy formulation
- Curriculum
- Achievement
- Teaching and instruction
- Background variable correlates with achievement

The Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics curriculum for Grade 4 covers the topics listed in Exhibit 1.

Exhibit 1: Grade 4 Mathematics National Curriculum, 2006⁵

Unit	Scope/Learning Outcomes of the 2006 Curriculum
1.1 Numbers	<ul style="list-style-type: none"> ▪ Identify place value of digits up to 100,000,000 ▪ Read and write numbers up to 100,000,000 ▪ Recognize numbers in words up to 100,000,000 ▪ Compare and order numbers up to eight digits
1.2 Addition and subtraction	<ul style="list-style-type: none"> ▪ Add and subtracts numbers up to six digits ▪ Solve real life problems involving addition and subtraction of numbers up to six digits
1.4 Multiplication	<ul style="list-style-type: none"> ▪ Multiply numbers up to five digits by numbers up to three digits ▪ Solve real life problems involving multiplication
1.5 Division	<ul style="list-style-type: none"> ▪ Divide numbers up to four digits by numbers up to two digits ▪ Solve real life problems involving division
1.6 Addition, subtraction, multiplication, and division	<ul style="list-style-type: none"> ▪ Use mixed operation of addition and subtraction and multiplication and division ▪ Solve real life problems involving addition, subtraction, multiplication, and division, and using Pakistani currency
2.1 Divisibility test	<ul style="list-style-type: none"> ▪ Identify divisibility tests for 2, 3, 5, and 10 ▪ Use divisibility tests for 2, 3, 5, and 10 on numbers up to five digits
2.2 Prime and composite numbers	<ul style="list-style-type: none"> ▪ Define prime and composite numbers ▪ Differentiate between prime and composite numbers
2.3 Factors and multiples	<ul style="list-style-type: none"> ▪ List factors of a number up to 50 ▪ List the first 12 multiples of one-digit numbers ▪ Differentiate between factors and multiples
2.4 Prime factorization	<ul style="list-style-type: none"> ▪ Factorize a number using prime factor
2.5 Highest common factor (HCF)	<ul style="list-style-type: none"> ▪ Determine common factors of two or more two-digit numbers ▪ Find the HCF of two or more natural numbers by Venn diagram ▪ Find HCF of two or more two-digit numbers using prime factorization ▪ Solve real life problems involving HCF

Unit	Scope/Learning Outcomes of the 2006 Curriculum
2.6 Least common multiple (LCM)	<ul style="list-style-type: none"> ▪ Determine common multiples of two or more two-digit numbers ▪ Find LCM by common multiples, prime factorization ▪ Find LCM by Prime factorization ▪ Solve real life problems involving LCM
3.1 Fractions	<ul style="list-style-type: none"> ▪ Define a fraction ▪ Recognize like and unlike fractions ▪ Compare two unlike fractions by converting them to equivalent fractions with the same denominators ▪ Arrange fractions in ascending and descending order ▪ Simplify fractions to the lowest form
3.2 Types of fraction	<ul style="list-style-type: none"> ▪ Identify unit, proper, improper, and mixed fractions ▪ Converting an improper fraction into a mixed fraction and vice versa
3.3 Addition and subtraction of fractions	<ul style="list-style-type: none"> ▪ Add fractions with unlike denominators ▪ Verify the commutative property of addition of fraction with same denominators ▪ Verify the associative property of addition of fraction with same denominators ▪ Subtract fractions with unlike denominators
3.4 Multiplication of fractions	<ul style="list-style-type: none"> ▪ Multiply fractions with whole numbers ▪ Multiply two or more fractions (proper, improper, and mixed fractions) ▪ Verify the commutative property of multiplication of fractions ▪ Verify the associative property of multiplications of fractions
3.5 Division of fractions	<ul style="list-style-type: none"> ▪ Divide a fraction by a whole number ▪ Divide a whole number by a fraction ▪ Divide a fraction by another fraction (proper, improper, and mixed fractions) ▪ Solve real life problems involving fractions using all four operations
4.1 Decimals	<ul style="list-style-type: none"> ▪ Know a decimal number as an alternate way of writing of fraction ▪ Define a decimal as a fraction with a denominator of 10 or a power of 10 ▪ Recognize the places occupied the digit after the decimal point as decimal places ▪ Identify the place value of a digit in decimals
4.2 Conversion between fraction and decimals	<ul style="list-style-type: none"> ▪ Convert a given fraction to a decimal if the denominator of the fraction is 10 or a power of 10 ▪ Convert a given fraction to a decimal if the denominator of the fraction is not a power of 10 but can be converted to a power of 10 ▪ Convert decimals (up to three decimal places) to fractions
4.3 Basic operations on decimals	<ul style="list-style-type: none"> ▪ Add and subtract decimals (up to two decimal places) ▪ Multiply a decimal by 10, 100, and 1,000 ▪ Multiply a decimal by a two-digit number ▪ Divide a decimal by a one-digit number (quotient being a decimal up to two decimal places) ▪ Solve real life problems involving decimal fractions up to two decimal places
5.1 Length, conversion of units of length, addition and subtraction of units of length	<ul style="list-style-type: none"> ▪ Convert kilometers to meters, meters to centimeters, and centimeters to millimeters ▪ Add and subtract expressions involving similar units of length ▪ Use appropriate units to measure the length of different objects ▪ Solve real life problems involving conversion, addition, and subtraction of units of length

Unit	Scope/Learning Outcomes of the 2006 Curriculum
5.2 Mass/weight, conversion of units of mass, weight, addition and subtraction of units of mass/weight	<ul style="list-style-type: none"> ▪ Convert kilograms to grams ▪ Add and subtract expressions involving similar units of mass/weight ▪ Use appropriate units to measure the mass/weight of different objects ▪ Solve real life problems involving conversion, addition, and subtraction of units of mass/weight
5.3 Volume/capacity, conversion of units of capacity, addition and subtraction of units of capacity	<ul style="list-style-type: none"> ▪ Convert liters to milliliters ▪ Add and subtract expression involving units of capacity/volume ▪ Use appropriate units to measure the capacity/volume of different objects ▪ Solve real life problems involving the conversion, addition, and subtraction of units of capacity/volume
5.4 Time, conversion of units of time, addition and subtraction of units of time	<ul style="list-style-type: none"> ▪ Read time and in hours, minutes, and seconds ▪ Convert hours to minutes and minutes to seconds ▪ Convert years to months, months to days, and weeks to days ▪ Add and subtract units of time without carrying/borrowing ▪ Solve simple real life problems involving conversion, addition, and subtraction of units of time
6.1 Geometry tools	<ul style="list-style-type: none"> ▪ Know instruments of geometry and geometry box (i.e., pencil, straightedge/ruler, compass, dividers, set square, and protractor) ▪ Recognize the use of pencils of grade H and HB ▪ Demonstrate the use of H and HB pencils by drawing different lines
6.2 Lines	<ul style="list-style-type: none"> ▪ Measure the length of a line in centimeters and millimeters using straightedge/ruler and dividers ▪ Draw a straight of given length using straight edge/ruler and dividers ▪ Draw a curved line and measure its length using threads/dividers and straightedges/ruler ▪ Recognize horizontal and vertical lines ▪ Draw a vertical line on a given horizontal line using set squares ▪ Recognize parallel and nonparallel lines ▪ Identify parallel and nonparallel lines from a given set of lines ▪ Draw a parallel line to a given straight line using set squares ▪ Draw a line that passes through a given point and is parallel to a given line (using a set square)
6.3 Angles	<ul style="list-style-type: none"> ▪ Recognize an angle through nonparallel lines ▪ Draw an angle AOB with vertex (O) and arms (OA, OB) to recognize the notation $\angle AOB$ for an angle AOB ▪ Recognize right angle through horizontal and vertical lines ▪ Demonstrate acute and obtuse angles via the right angle ▪ Recognize the standard unit of measuring angles as one degree, which is defined as $1/360$ of a complete revolution ▪ Measure angles using protractor where the upper scale of protractor reads the measure of angle from left to right and the lower scale of protractor reads the measure of angle from right to left ▪ Draw a right angle using protractor ▪ Draw acute and obtuse angle of different measures using protractor ▪ Draw an angle (using protractor): equal in measure of a given angle, twice the measure of a given angle, equal in measure of the sum of two given angles

Unit	Scope/Learning Outcomes of the 2006 Curriculum
6.4 Circles	<ul style="list-style-type: none"> Identify the center, radius, diameter, and circumference of a circle Draw a circle of a given radius using compasses and straightedge/ruler
6.5 Quadrilaterals	<ul style="list-style-type: none"> Construct squares and rectangles with size of given measure using a protractor, set square, and straightedge/ruler
7.1 Bar graphs	<ul style="list-style-type: none"> Read and interpret simple bar graphs given in horizontal and vertical form
7.2 Line graphs	<ul style="list-style-type: none"> Read and interpret a line graph

Exhibit 2 lists elements of the Grade 8 mathematics curriculum.

Exhibit 2: Grade 8 Mathematics National Curriculum, 2006⁶

Unit	Scope/Learning Outcomes of the 2006 Curriculum
1.1 Sets	<ul style="list-style-type: none"> Natural number (N) Whole numbers (W) Integers (Z) Rational number (Q) Even number (E) Odd number (O) Prime number (P) Find a subset of a set Define proper and improper subsets of a set Find power set $P(A)$ of a set A
1.2 Operations on sets	<ul style="list-style-type: none"> Verify commutative and associative laws with respect to union and intersection Verify the distributive laws State and verify De Morgan's laws
1.3 Venn diagrams	<ul style="list-style-type: none"> Demonstrate union and intersection of three overlapping sets through a Venn diagram Verify associative and distributive laws through Venn diagram
2.1 Irrational Number	<ul style="list-style-type: none"> Define an irrational number Recognize rational and irrational numbers Define real numbers Demonstrate nonterminating/nonrepeating (or nonperiodic) decimals
2.2 Squares	<ul style="list-style-type: none"> Find perfect square of a number Establish patterns for the squares of natural number (e.g., $4^2 = 1 + 2 + 3 + 4 + 3 + 2 + 1$)
2.3 Square roots	<ul style="list-style-type: none"> Find square root of: a natural number (e.g., 16, 625, 1600), a common fraction (e.g., $9/16$, $36/49$, $49/64$), a decimal (e.g., 0.01, 1.21, 0.64) given in perfect square form by prime factorization and division method Find the square root of a number that is not a perfect square (e.g., 2, 3, and 2.5). Use the following rule to determine the number of digits in the square root of a perfect square: Let n be the number of digits in the perfect square then its square root contains $n/2$ digits if n is even, and $(n+1)/2$ digits if n is odd Solve real life problems involving square roots
2.4 Cubes and cube roots	<ul style="list-style-type: none"> Recognize cubes and perfect cubes Find cube roots of a number that are perfect cubes Recognize properties of cubes of numbers

Unit	Scope/Learning Outcomes of the 2006 Curriculum
3.1 Number system	<ul style="list-style-type: none"> ▪ Recognize base of a number system ▪ Define number system with base 2, 5, 8, and 10 ▪ Explain the binary number system (system with base 2), the number system with base 5, the octal number system (system with base 8), the decimal number system (system with base 10)
3.2 Conversions	<ul style="list-style-type: none"> ▪ Convert a number from a decimal system to a system with base 2, 5, and 8, and vice versa ▪ Add, subtract, and multiply numbers with base 2, 5, and 8 ▪ Add, subtract, and multiply numbers with different bases
4.1 Compound proportion	<ul style="list-style-type: none"> ▪ Define compound proportion ▪ Solve real life problems involving compound proportion, partnership, and inheritance
4.2 Banking 4.2.1 Types of a bank account 4.2.2 Online banking 4.2.3 Conversion of currencies 4.2.4 Profit/Markup 4.2.5 Types of finance	<ul style="list-style-type: none"> ▪ Define commercial bank deposits, types of a bank account (PLS savings bank account, current deposit account, PLS term deposit account and foreign currency account) ▪ Describe negotiable instruments like checks, withdrawals, and money orders ▪ Explain online banking and transactions through an automated teller machine (ATM), debit card, and credit card ▪ Convert Pakistani currency to well-known international currencies. ▪ Profit/markup ▪ Principal amount ▪ Profit/markup rate period ▪ Explain overdraft (OD), running finance (RF), demand finance (DF), leasing ▪ Solve real life problems related to banking and finance
4.3 Percentage 4.3.1 Profit and loss 4.2.3 Discount	<ul style="list-style-type: none"> ▪ Find percentage profit and percentage loss ▪ Find percentage discount ▪ Solve problems involving successive transactions
4.4 Insurance	<ul style="list-style-type: none"> ▪ Define insurance ▪ Solve real life problems regarding life and vehicle insurance
4.5 Income tax	<ul style="list-style-type: none"> ▪ Explain income tax, exempt income, and taxable income ▪ Solve simple real life problems related to individual income tax assessment
5.1 Algebraic expression	<ul style="list-style-type: none"> ▪ Recall constant, variable, literal, and algebraic expression
5.2 Polynomials	<ul style="list-style-type: none"> ▪ Define: polynomials, degree of a polynomial, coefficients of a polynomial ▪ Recognize polynomial with one, two, and more variables ▪ Recognize polynomials of various degrees (e.g., linear, quadratic, cubic, and biquadratic polynomials)
5.3 Operations on polynomials	<ul style="list-style-type: none"> ▪ Add, subtract, and multiply polynomials ▪ Divide a polynomial by a linear polynomial
6.1 Basic algebraic formulas	<ul style="list-style-type: none"> ▪ Recall the formulas <ul style="list-style-type: none"> □ $(a + b)^2 = a^2 + 2ab + b^2$ □ $(a - b)^2 = a^2 - 2ab + b^2$ □ $a^2 - b^2 = (a - b)(a + b)$ ▪ Apply above formulas to solve problems like: <ul style="list-style-type: none"> □ Evaluate $(102)^2$, $(1.02)^2$, $(98)^2$ and $(0.98)^2$ □ Find $x^2 + \frac{1}{x^2}$ and $x^4 + \frac{1}{x^4}$ when the value of $x + \frac{1}{x}$ is given

Unit	Scope/Learning Outcomes of the 2006 Curriculum
6.2 Factorization	<ul style="list-style-type: none"> ▪ Factor expressions of the following types <ul style="list-style-type: none"> ▫ $ka + kb + kc$ ▫ $ac + ad + bc + bd$ ▫ $a^2 \pm 2ab + b^2$ ▫ $a^2 - b^2$ ▫ $a^2 \pm 2ab + b^2 - c^2$
6.3 Manipulation of algebraic expression	<ul style="list-style-type: none"> ▪ Recognize the formulas: <ul style="list-style-type: none"> ▫ $(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$ ▫ $(a - b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$ ▪ Apply these formulas to solve the problems such as: <ul style="list-style-type: none"> ▫ Find $x^3 + \frac{1}{x^3}$ and $x^3 - \frac{1}{x^3}$ when the value of $x \pm \frac{1}{x}$ is given
6.4 Simultaneous linear equations	<ul style="list-style-type: none"> ▪ Recognize simultaneous linear equations in one and two variables ▪ Give the concept of formation of linear equation in two variables ▪ Know that: <ul style="list-style-type: none"> ▫ A single linear equation in two unknown is satisfied by as many pair of values as required ▫ Two linear equations in two unknowns have only one solution (i.e., one pair of values)
6.5 Solution of simultaneous linear equations	<ul style="list-style-type: none"> ▪ Solve simultaneous linear equations using: <ul style="list-style-type: none"> ▫ Method of equating the coefficients ▫ Method of elimination by substitution ▫ Method of cross multiplication ▪ Solve real life problems involving two simultaneous linear equations in two variables
6.6 Elimination	<ul style="list-style-type: none"> ▪ Eliminate a variable from two equations by substitution and application of formulas
7.1 Parallel lines	<ul style="list-style-type: none"> ▪ Define parallel lines ▪ Demonstrate through figures the following properties of parallel lines: <ul style="list-style-type: none"> ▫ Two lines that are parallel to the same given line are parallel to each other ▫ If three parallel lines are intersected by two transversals in such a way that the two intercepts on one transversal are equal to each other, the two intercepts on the second transversal are also equal ▫ A line through the midpoint of the side of a triangle parallel to another side bisects the third side (an application of above property) ▪ Draw a transversal to intersect two parallel lines and demonstrate corresponding angles, alternate interior angles, vertically opposite angles and interior angles on the same side of a transversal ▪ Describe the following relationships between the pairs of angles when a transversal intersects two parallel lines and demonstrate the relationships through figures: <ul style="list-style-type: none"> ▫ Pairs of corresponding angles are equal ▫ Pairs of alternate interior angles are equal ▫ Pairs of interior angles on the same side of transversal are supplementary

Unit	Scope/Learning Outcomes of the 2006 Curriculum
7.2 Polygons	<ul style="list-style-type: none"> ▪ Define a polygon ▪ Demonstrate the following properties of a parallelogram: <ul style="list-style-type: none"> ▫ Opposite sides of a parallelogram are equal ▫ Opposite angles of a parallelogram are equal, diagonals of a parallelogram bisect each other ▫ Diagonals of a parallelogram bisect each other ▪ Define regular pentagon, hexagon, and octagon
7.3 Circles	<ul style="list-style-type: none"> ▪ Demonstrate a point lying in the interior and exterior of a circle ▪ Describe the terms; sector, secant, and chord of a circle; concyclic points; tangent to a circle and concentric circles
8.1 Construction of quadrilaterals	<ul style="list-style-type: none"> ▪ Define and depict two converging (nonparallel) lines and find the angle between them without producing the lines ▪ Bisect the angle between the two converging lines without producing them ▪ Construct a square: <ul style="list-style-type: none"> ▫ When its diagonal is given ▫ When the difference between its diagonal and side is given ▫ When the sum of its diagonal and side is given ▪ Construct a rectangle: <ul style="list-style-type: none"> ▫ When two sides are given ▫ When the diagonal and a side are given ▪ Construct a rhombus: <ul style="list-style-type: none"> ▫ When one side and the base angle are given ▫ When one side and a diagonal are given ▪ Construct a parallelogram: <ul style="list-style-type: none"> ▫ When two diagonals and the angle between them is given ▫ When two adjacent sides and the angle included between them is given ▪ Construct a kite when two unequal sides and a diagonal are given ▪ Construct a regular pentagon when a side is given ▪ Construct a regular hexagon when a side is given
8.2 Construction of a right triangle	<ul style="list-style-type: none"> ▪ Construct a right triangle: <ul style="list-style-type: none"> ▫ When the hypotenuse and one side are given ▫ When the hypotenuse and the vertical height from its vertex to the hypotenuse are given
9.1 The Pythagorean theorem	<ul style="list-style-type: none"> ▪ State the Pythagorean theorem and give its informal proof ▪ Solve right triangles using the Pythagorean theorem
9.2 Hero's formula	<ul style="list-style-type: none"> ▪ State and apply Hero's formula to find the areas of triangular and quadrilateral regions.
9.3 Surface area and volume	<ul style="list-style-type: none"> ▪ Find the surface area and volume of a sphere ▪ Find the surface area and volume of a cone ▪ Solve real life problems involving surface area and volume of sphere and cone
10.1 Demonstrative geometry 10.1.1 Reasoning 10.1.2 Axioms postulates and theorem	<ul style="list-style-type: none"> ▪ Define demonstrative geometry ▪ Describe the basics of reasoning ▪ Describe the types of assumptions (axioms and postulates) ▪ Describe parts of a proposition. ▪ Describe the meanings of a geometrical theorem, corollary, and converse of a theorem

Unit	Scope/Learning Outcomes of the 2006 Curriculum
10.2 Theorems	<ul style="list-style-type: none"> ▪ Prove the following theorems along with corollaries and apply them to solve appropriate problems: <ul style="list-style-type: none"> ▫ If a straight line stands on another straight line, the sum of measures of two angles so formed is equal to two right angles ▫ If the sum of measures of two adjacent angles is equal to two right angles, the external arms of the angles are in a straight line ▫ If two lines intersect each other, then the opposite vertical angles are congruent ▫ In any correspondence of two triangles, if two sides and the included angle of one triangle are congruent to the corresponding sides and included angle of the other, the two triangles are congruent ▫ If two sides of a triangle are congruent, then the angles opposite to these sides are congruent ▫ An exterior angle of a triangle is greater in measure than either of its opposite interior angles ▫ If a transversal intersects two lines such that the pair of alternate angles are congruent then the lines are parallel ▫ If a transversal intersects two parallel lines, the alternate angles so formed are congruent ▫ The sum of measures of the three angles of a triangle is 180 degrees
11.1 Trigonometry 11.2 Trigonometric Ratios of acute angles	<ul style="list-style-type: none"> ▪ Define trigonometry ▪ Define trigonometric ratios of an acute angle. ▪ Find trigonometric ratios of acute angles (30, 60, and 45 degrees) ▪ Define trigonometric ratios of complementary angles ▪ Solve right triangles using trigonometric ratios ▪ Solve real life problems to find heights (avoid naming angle of elevation)
12.1 Frequency distribution	<ul style="list-style-type: none"> ▪ Define frequency, frequency distribution ▪ Construct frequency table ▪ Construct a histogram representing frequency table
12.2 Measures of central tendency	<ul style="list-style-type: none"> ▪ Describe measures of central tendency ▪ Calculate mean (average), weighted mean, median, and mode for ungrouped data ▪ Solve real life problems involving mean (average), weighted mean, median, and mode

The Science Curriculum in Primary and Lower Secondary Grades

Exhibit 3 lists the contents and outcomes of the science curriculum for fourth grade.

Exhibit 3: Science Curriculum for Fourth Grade⁷

Topics	Student Learning Outcomes
<p>Understanding Ourselves</p> <ul style="list-style-type: none"> Introduction to human body Major body parts and their functions (teeth, bones, muscles, brain, lung, heart, stomach, skin, eyes, and ears) Common disorders of some parts of human body (skin, teeth, and stomach) 	<ul style="list-style-type: none"> Identify major parts of human body State functions of major parts of the body Describe how bones and muscles work together to produce movement Identify common disorders of various parts of body and their causes Suggest ways to keep parts of their body healthy
<p>Characteristics and Needs of Living Things</p> <ul style="list-style-type: none"> Need food, sunlight, air, and water to survive Move, grow, reproduce, and maintain the continuity of life (characters are inherited, similarities and differences within species) Animal lifecycles (frog, butterfly, and bee) Plant lifecycle (germination of seed to the production of a flower) 	<ul style="list-style-type: none"> Characteristics and needs of living things Need food, sunlight, air, and water to survive Move, grow, reproduce, and maintain the continuity of life (characteristics are inherited, similarities and differences within species) Animal life cycles (frog, butterfly, and bee) Plant life cycle (Germination of seed to the production of a flower)
<p>Human Health</p> <ul style="list-style-type: none"> Sources of food groups (fruits, vegetables, meat, pulses, and cereals) Main groups of food (carbohydrates, proteins, minerals, vitamins, and fats) and their properties Balanced diet and its importance Hygiene and basic principles 	<ul style="list-style-type: none"> Identify the sources of common food Explain the properties of major food groups Classify different food into their basic groups Interpret a food pyramid to show the relative importance of various food groups Differentiate between balanced and unbalanced diet Suggest a balanced meal from the given list of foods and give reasons to explain why each food was chosen Explain the effects of unbalanced diet on health Explain hygiene and its basic principles
<p>Living Things and Their Environment</p> <ul style="list-style-type: none"> Environment and its components (living and nonliving) Ecosystem and its types Classification of animals according to eating habits (herbivores, carnivores, and omnivores) Introduction to simple food chain (producers, consumers, and decomposers) 	<ul style="list-style-type: none"> Define environment Explain components of environment with examples Differentiate between various types of environment Explain the characteristics of animals and plants that enable them to survive in a particular environment Classify animals on the basis of food they eat Differentiate between carnivores, herbivores, and omnivores with the help of examples Define producers, consumers, and decomposers Explain the importance of producers, consumers, and decomposers in a food chain Make a simple food chain to show the relationship between producers, consumers, and decomposers

Topics	Student Learning Outcomes
<p>Matter and its States</p> <ul style="list-style-type: none"> ▪ Introduction to three states of matter (shape and volume) ▪ Effect of heat on solids, liquids and gases ▪ Mixing of materials ▪ Soluble and insoluble solids ▪ Soluble and insoluble solids from water (by decantation and filtration) 	<ul style="list-style-type: none"> ▪ Define matter and give examples. ▪ Identify three states of matter with examples ▪ Compare solids, liquids, and gases on the basis of shape and volume ▪ Demonstrate and explain how matter changes its state on heating ▪ Explain how one state of matter (solid, liquid, gas) dissolves in other ▪ Predict and demonstrate how various materials mix with water ▪ Demonstrate separation of insoluble solids from water by decantation and filtration
<p>Heat and its Measurement</p> <ul style="list-style-type: none"> ▪ Heat and temperature ▪ Common scales of temperature (centigrade and Fahrenheit) ▪ Measurement of temperature (laboratory and clinical thermometers) ▪ Safety measures in using thermometers 	<ul style="list-style-type: none"> ▪ Define heat and temperature ▪ Draw and label the device for measuring temperature ▪ Measure and record the body temperature using a laboratory thermometer and a clinical thermometer ▪ Suggest the safety measures required in using thermometers
<p>Force and Machines</p> <ul style="list-style-type: none"> ▪ Force, effects of force (in changing position and shape) ▪ Speed ▪ Introduction to simple machines (scissors, hammer, pulley, wheelbarrow) 	<ul style="list-style-type: none"> ▪ Define force by giving examples ▪ Investigate the ways in which motion of an object can be changed ▪ Demonstrate how force can change the position and the shape of an object ▪ Explore that greater the force, greater the change in the distance covered by the object ▪ Design experiments to demonstrate that some objects can return to their original shape after the release of force ▪ Define speed and give its relationship with distance ▪ Define simple machines by giving examples of commonly used machines from the environment ▪ Design an experiment to show how simple machines make work easier
<p>Introduction to Sound</p> <ul style="list-style-type: none"> ▪ Sound ▪ How sound is produced ▪ Intensity of sound (high and low) ▪ Medium (solids, liquids, and air) for sound to travel ▪ Noise and its effects on human health ▪ Measures to reduce/control noise pollution 	<ul style="list-style-type: none"> ▪ Investigate that sound is produced by vibrating objects ▪ Differentiate between low and high sounds ▪ Demonstrate that sound can travel through solids, liquids, and gases but cannot travel through a vacuum ▪ Interpret that the explosions in the core of the sun is not heard, as sound cannot travel through vacuum ▪ Differentiate between noise and other sounds ▪ Explore the effects of noise on human health ▪ Suggest ways to reduce noise pollution and plan an awareness campaign on any one
<p>Investigating Electricity and Magnetism</p> <ul style="list-style-type: none"> ▪ Introduction to conductors and insulators ▪ Simple circuit switches (open and closed) 	<ul style="list-style-type: none"> ▪ Distinguish between insulators and conductors ▪ Identify examples of conductors and insulators in their environment

Topics	Student Learning Outcomes
<ul style="list-style-type: none"> ▪ Natural and artificial magnets ▪ Magnetic and nonmagnetic materials ▪ Properties and uses of a magnet ▪ Methods of magnetizing material ▪ Demagnetizing ▪ Temporary and permanent magnets 	<ul style="list-style-type: none"> ▪ Make a simple electric circuit ▪ Differentiate between an open and closed electric circuit ▪ Investigate using a magnet that some materials are magnetic and some are nonmagnetic ▪ Recognize that a magnet has poles ▪ Demonstrate that like poles repel each other and unlike poles attract each other ▪ Investigate that a freely suspended magnet always points in a north/south direction ▪ Identify the various uses of magnets and magnetic materials in daily life ▪ Demonstrate that how magnets can be formed and stored ▪ Differentiate between temporary and permanent magnets
<p>Movements of the Earth</p> <ul style="list-style-type: none"> ▪ Earth ▪ Earth's spin ▪ Day and night ▪ Revolution ▪ Seasons 	<ul style="list-style-type: none"> ▪ Describe the shape of Earth ▪ Relate the Earth's spin with the occurrence of day and night ▪ Define the term revolution ▪ Identify that the distance between the Earth and the sun affects the time Earth takes to revolve around the sun ▪ Explain that the Earth is tilted on its axis and this tilt causes seasons

Exhibit 4 lists the content and learning outcomes for science in eighth grade.

Exhibit 4: Science Curriculum for Eighth Grade

Contents	Student Learning Outcomes
<p>Human Organ Systems</p> <ul style="list-style-type: none"> ▪ Nervous system (central and peripheral) ▪ Reflex action ▪ Excretory system (structure of kidney and its role in excretion) 	<ul style="list-style-type: none"> ▪ Describe the structure and functions of the nervous system ▪ Describe the working of the nervous system through a model ▪ Explain reflex action with an example ▪ Differentiate between voluntary and involuntary actions they have experienced ▪ Define excretion ▪ Draw and label human excretory system ▪ Describe the role of kidney in excretion of waste ▪ Investigate the possible causes of the malfunctioning of kidneys ▪ Suggest techniques to cure problems of kidneys
<p>Heredity in Organisms</p> <ul style="list-style-type: none"> ▪ Cell division ▪ Heredity ▪ Basis of heredity (chromosomes, DNA, and genes in plant and animal cells) 	<ul style="list-style-type: none"> ▪ Differentiate between mitosis and meiosis ▪ Identify DNA and chromosomes in the cell diagram ▪ Define heredity and recognize its importance in transferring of characteristics from parents to offspring ▪ Identify the characteristics that can be transferred from parents to offspring ▪ Compare characteristics related to ear and eye color
<p>Biotechnology</p> <ul style="list-style-type: none"> ▪ Biotechnology ▪ DNA replication ▪ Introduction of gene into bacterium ▪ Genetic modifications (microorganism resistance, improved nutrition and quality of food) ▪ Biotechnology products saving lives (insulin, vaccines) ▪ General applications (agriculture, environment, health, food production and preservation) 	<ul style="list-style-type: none"> ▪ Define biotechnology ▪ Explain how DNA is copied and made ▪ Describe the relationship between DNA, genes, and chromosomes ▪ Define bacterium ▪ Explain how genes are introduced into a bacterium ▪ List some biotechnological products used in daily life ▪ Explain that genetic modification in different foods can increase the amounts of essential nutrients ▪ List general applications of biotechnology in various fields ▪ Explain how biotechnology allows meeting the nutritional needs of growing populations
<p>Pollutants and Their Effects on Environment</p> <ul style="list-style-type: none"> ▪ Air Pollutants (sulfur dioxide, carbon monoxide) ▪ Oxides of nitrogen, chlorofluorocarbons ▪ Sources (natural and from human activities) ▪ Harmful effects (on human organ systems: lung diseases, brain damage, breathing, headaches) ▪ Effects of human activity on environment (greenhouse effect, ozone depletion, and global warming), acid rain, wildlife, deforestation, ▪ Lack of energy resources 	<ul style="list-style-type: none"> ▪ Explain the sources, properties, and harmful effects of air pollutants ▪ List problems in human organ systems caused by air pollutants ▪ Plan and conduct a campaign that can help to reduce air pollution in their local environment ▪ Explain the Greenhouse effect ▪ Describe the causes and effects of ozone depletion ▪ Carry out research to explain global warming and its likely effects on life on earth.

Contents	Student Learning Outcomes
<ul style="list-style-type: none"> ▪ Saving the Earth (solid waste management) ▪ Recycling of materials, ▪ Conservation of resources, ▪ Environmental campaigns ▪ Personal responsibility 	<ul style="list-style-type: none"> ▪ Design a model to explain the greenhouse effect. ▪ Explain the formation of acid rain and identify its consequences on living and nonliving things ▪ Define deforestation ▪ State the effects of deforestation on the environment ▪ Identify human activities that have long-term adverse consequences on the environment ▪ Explain the importance of local and global conservation of natural resources ▪ Suggest ways in which individuals, organizations, and government can help to make earth a better place to live.
<p>Chemical Reactions</p> <ul style="list-style-type: none"> ▪ Chemical reactions (definition and applications) ▪ Chemical equations and balancing ▪ Law of conservation of mass ▪ Types of chemical reactions (addition and decomposition) ▪ Energy changes in chemical reactions (exothermic and endothermic) 	<ul style="list-style-type: none"> ▪ Define a chemical reaction and give examples: ▪ Explain the rearrangement of atoms in chemical reactions ▪ Explain the balancing of a chemical reaction ▪ Define the law of conservation of mass ▪ Identify the nature of a chemical change in various reactions ▪ Describe changes in the states of matter in a chemical reaction ▪ Explain the types of chemical reactions with examples ▪ Explain the energy changes in chemical reactions ▪ Describe the importance of exothermic reactions in daily life
<p>Acids, Alkalis, and Salts</p> <ul style="list-style-type: none"> ▪ Introduction to acids, alkalis, and salts ▪ Properties of acids, alkalis, and salts ▪ Uses of acids, alkalis, and salts ▪ pH and its range (1–14) in aqueous medium ▪ Indicators and their uses (natural indicators from fruits and vegetables) 	<ul style="list-style-type: none"> ▪ Define the terms acid, alkali, and salt ▪ Describe the properties of acids, alkalis, and salts ▪ Explain the uses of acid, alkali, and salt in daily life ▪ Define indicators ▪ Use indicators to identify acids, alkalis, and neutral substances ▪ Investigate the color changes in the extracts of various flowers and vegetables by adding acids and alkalis
<p>Force and Pressure</p> <ul style="list-style-type: none"> ▪ Pressure, force, and area ▪ Units (N/m² and Pascal) ▪ Hydraulics and hydraulic systems ▪ Water pressure ▪ Pneumatics (how gases behave under pressure) ▪ Gas pressure in a container ▪ Aerosols ▪ Atmospheric pressure 	<ul style="list-style-type: none"> ▪ Define the term pressure ▪ Identify the units of pressure ▪ Explain hydraulics and hydraulic system by giving examples ▪ Explain how gases behave under pressure ▪ Describe the causes of gas pressure in a container ▪ Explain the working of aerosols ▪ Identify the application of gas pressure ▪ Describe the term atmospheric pressure
<p>Measurements of Physical Quantities</p> <ul style="list-style-type: none"> ▪ Physical quantities (length, volume, mass, time) ▪ International System of Units (SI units; meter, liter, kilogram, second) 	<ul style="list-style-type: none"> ▪ Define a physical quantity with examples ▪ Apply the prefixes milli-, kilo-, and centi-, and interpret the units ▪ Convert smaller units and bigger units

Contents	Student Learning Outcomes
<ul style="list-style-type: none"> ▪ Instruments for measurements (meter rule, measuring cylinder, flasks, pipette) 	<ul style="list-style-type: none"> ▪ Select and use measuring instruments ▪ Interpret SI units in the daily life ▪ Investigate why it is desirable for a scientist to use SI units ▪ Measure the volume of liquid by reading meniscus
<p>Sources and Effects of Heat Energy</p> <ul style="list-style-type: none"> ▪ Sources and effects of heat ▪ Thermal expansion and contraction (solids, liquids and gases) ▪ Applications of expansion and contraction of solids (riveting, fixing a metal tire onto wheel, fixing axle of a wheel, fire alarms, and electric irons) ▪ Effects of expansion and contraction of solids in everyday life (concrete road surfaces, railway tracks, bridges, overhead powers, telephone lines, pipelines) ▪ Uses of expansion and contraction of liquids ▪ Peculiar behavior of water during contraction and expansion 	<ul style="list-style-type: none"> ▪ Describe the sources and effects of heat ▪ Explain thermal expansion of solids, liquids, and gases ▪ Explore the effects and applications of expansion and contraction of solids ▪ Describe the uses of expansion and contraction of liquids ▪ Explain the peculiar behavior of water during contraction and expansion ▪ Investigate the processes making use of thermal expansion of substances ▪ Identify the damages caused by expansion and contraction in their surroundings and suggest ways to reduce these damages ▪ Investigate the means used by scientists and engineers to overcome the problems of expansion and contraction in everyday life ▪ Describe the working of a thermometer
<p>Lenses</p> <ul style="list-style-type: none"> ▪ Lenses ▪ Types of lenses (converging and diverging lenses) ▪ Image formation by ray diagram ▪ Image formation in simple camera and human eye ▪ Uses of lenses 	<ul style="list-style-type: none"> ▪ Define lens ▪ Differentiate between the different types of lenses ▪ Describe the image formation using a lens by ray diagram ▪ Compare and contrast the working of a human eye with the lens camera ▪ Explain how an eye focuses by altering the thickness of the eye lens ▪ Investigate how eyes get used to darkness ▪ Explain how lenses are used to correct short sightedness and long sightedness ▪ Identify the types of lenses used for various purposes in daily life
<p>Electricity in Action</p> <ul style="list-style-type: none"> ▪ Generating electricity (model generator) ▪ Portable generator (bicycle dynamo) ▪ Problem of generating electricity ▪ Power stations ▪ Other sources of electricity ▪ Introduction to electronic systems ▪ Uses of components (input, processor, output) 	<ul style="list-style-type: none"> ▪ Design an experiment to generate electricity ▪ Explain the working of a model generator ▪ Identify the simple devices that generate electricity in daily life ▪ Design and demonstrate the working of a power station ▪ List types of energy being used in power stations ▪ Relate problems involved in generating electricity ▪ Describe basic components of an electronic system ▪ List components that would be needed to turn alternating current to direct current ▪ State how output components in various devices could be used in their schools and surroundings

Contents	Student Learning Outcomes
Exploring Space <ul style="list-style-type: none"> ▪ Telescopes, spacecraft ▪ Spectroscopes ▪ Space exploration 	<ul style="list-style-type: none"> ▪ Describe development of tools and technologies used in space exploration ▪ Analyze the benefits generated by the technology of the space exploration ▪ Explain how astronauts survive and research in space ▪ Suggest the ways to solve the problems that have resulted from space exploration ▪ Identify the technological tools used in space exploration ▪ Identify new technologies used on earth that have developed as a result of the development of space technology ▪ Design a spacecraft and explain the key features of design to show its suitability as a spacecraft

Professional Development Requirements and Programs

Professional development is a continuing process, and a number of institutions offer preservice and in-service professional development programs across the country.⁸ Exhibit 5 offers some details regarding these institutions.

Exhibit 5: Number of Institutions' Offering Public and Private Preservice Professional Development Programs in Pakistan (Public and Private)

Province	Number of Institutions
Punjab	64
Khyber Pakhtunkhwa	83
Balochistan	29
Sindh	69
Gilgit Baltistan	12
Azad Jammu and Kashmir (AJK)	15
Federally Administered Tribal Areas (FATA)	4
Islamabad Capital Territory (ICT)	8
Total	284

The following teacher training institutions cover almost all subjects, including mathematics and science:

- AEPAM, Islamabad
- Directorate of Staff Development, Education Department, Lahore
- Directorate of Curriculum and Teacher Education (DCTE), Abbottabad
- Provincial Institute for Teacher Education (PITE), Peshawar
- PITE, Sindh

- PITE, Quetta
- Education and Literacy Department, Bureau of Curriculum and Extension Wing Sindh, Jamshoro
- Education Directorate, Bureau of Curriculum and Extension Centre (BoC & EC), Quetta
- Aga Khan University
- Institute of Teaching in GB
- Agha Khan University Karachi
- GCET AJK
- Universities in private sector
- Ali Institute of Teacher Training
- AIOU
- University of Education

Monitoring Student Progress in Mathematics and Science

The National Education Assessment System (NEAS) comprises public institutions that periodically monitor the progress of students at a national level. NEAS conducts several large scale studies of mathematics and science achievement. Exhibit 6 lists results for Grade 4 based on a scale of 0 to 1,000, where the minimum standard of proficiency is 500. Exhibit 7 lists results for Grade 8.

Exhibit 6: Student Achievement Results in Mathematics and Science at Grade 4

Year	Mathematics	Science
2005	421	-
2006	404	467
2008	369	-
2014	-	433
2016	484	-

Exhibit 7: Student Achievement Results in Mathematics and Science at Grade 8

Year	Mathematics	Science
2007	457	-
2008	-	467
2014	461	-
2016 - 2017	-	478

The above findings show that students have not achieved minimum standards in the core subjects of mathematics and science.

Special Initiatives in Mathematics and Science Education

The Ministry of Federal Education and Professional Training has developed a Single National Curriculum (SNC) at the elementary level in consultation with provincial and area education departments. The SNC for mathematics and science has made these subjects more student-centric than teacher-centric. Each unit or topic incorporates internet links that enable students and teachers to access relevant material in form of activities, grids, videos, and worksheets; the process nurtures students' life skills along with teaching content. Phase I of the SNC will be implemented simultaneously in public and private institutions across the country at the primary level (Grades 1 to 5) during the 2021–2022 school year.⁹

Provincial and area education departments have established a school monitoring unit. The main objectives of this initiative are to ensure that data for all key performance indicators are collected monthly, to improve governance, service delivery outcomes, planning, and resource allocation.^{10,11}

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