Appendix A

Comparison

Number Concepts and Operations

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grades K to 1	Recognize, describe, and use numbers from 0 to 100 in a variety of familiar settings. Demonstrate and use a variety of methods to show the process of addition and subtraction on one-digit whole numbers.	• Chess pieces values of 0, 1, 3, 5, and 9 • Counting chess pieces values • Compare object with values • Understand the concept of "half" of the chessboard	• Skip count to 100 by 1s, 2s, 5s, and 10s. • Estimating and Comparing estimates • Addition and subtraction to 18.	• Algebraic notation • Cancellation of equal values of chess pieces. • Counting in multi-direction with multiple attacks • Special tactics pattern • Chess pieces movements • Checkmate pattern • Attacking sequence • Interaction square • Logic
Grades 2 to 3	Develop a number sense for whole numbers from 0 to 1000 and common fractions to tenths. Use a variety of strategies to apply a basic operations $(+, -, \times, \div)$ to whole numbers and use these operations in solving problems.	• Chess pieces values of 0, 1, 3, 5, and 9 • Counting chess pieces values • Compare object with values • Understand the concept of "half" of the chessboard	• Estimating Rounding to the nearest 10 and 100 • Skip count forward and backward by 2s, 5s, 10s, 25s, and 100s to 1000. • Writing number in words • Place vales • Divisibility by 2, 5, 10 • Multiplication up to 25 (5×5) • Even and odd • Understanding of halves, thirds, fourths, fifths, and tenths.	• Algebraic notation • Cancellation of equal values of chess pieces. • Counting in multi-direction with multiple attacks • Special tactics pattern • Chess pieces movements • Checkmate pattern • Attacking sequence • Interaction square • Logic

Comparison

Number Concepts and Operations

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grade 4	Demonstrate a number sense for whole numbers from 0 to 10000 and for proper fractions. Apply arithmetic operations on whole numbers and illustrate their use in solving problems.	• Chess pieces values of 0, 1, 3, 5, and 9 • Counting chess pieces values • Compare object with values	• Estimating • Rounding to the nearest 10, 100, and 1000 • Skip counting • Writing number in words • Connect proper fractions to decimal fractions (tenths and hundredths) • Multiplication up to 9×9	• Algebraic notation • Cancellation of equal values of chess pieces. • Counting in multi-direction with multiple attacks • Special tactics pattern • Chess pieces movements • Checkmate pattern • Attacking sequence • Interaction square • Logic
Grade 5	Demonstrate a number sense for whole numbers, from 0 to 100000, and will explore proper fractions and decimal fractions. Apply arithmetic operations on whole numbers and decimal fractions and illustrate the use of decimal fractions in solving problems.	• Chess pieces values of 0, 1, 3, 5, and 9 • Counting chess pieces values • Compare object with values	• Place value from hundredths • Read and write numerals to a million • Estimate up to 100000 • Recognize multiples, factors, composites, and primes • Describe proper fractions, equivalent fractions • ddd $\times$ dd • ddd $\div$ d • dd.dd $\times$ d • dd.dd $\div$ d	• Algebraic notation • Cancellation of equal values of chess pieces. • Counting in multi-direction with multiple attacks • Special tactics pattern • Chess pieces movements • Checkmate pattern • Attacking sequence • Interaction square • Logic

Comparison

Number Concepts and Operations

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grade 6	Develop a number sense for common fractions and explore number sense for whole numbers. Apply arithmetic operations on whole numbers and decimal fractions in solving problems.	• Chess pieces values of 0, 1, 3, 5, and 9 • Counting chess pieces values • Compare object with values	• Read and write numerals > a million • Multiples, factors, composites, and primes • Exponent • Integers • Compare fractions, mixed numbers, and decimal fractions • Ratio and percentage	• Algebraic notation • Cancellation of equal values of chess pieces. • Counting in multi-direction with multiple attacks • Special tactics pattern • Chess pieces movements • Checkmate pattern • Attacking sequence • Interaction square • Logic
Grade 7	Demonstrate a number sense for decimal fractions and integers (including whole numbers). Apply arithmetic operations on decimal fractions and integers and illustrate their use in solving problems.	• Chess pieces values of 0, 1, 3, 5, and 9 • Counting chess pieces values • Compare object with values • Set theory for common factors • Decision for prime factorization • Attacking sequence for order of operations	• Common multiples, common factors, least common multiples, greatest common factors, and prime factorization • Order of operations • Scientific notation • Divisibility rules by 2, 3, 4, 5, 6, 8, 9, 10, or 11 • Expand standard numbers in posers of 10. • All 4 operations $(+, -, \times, \div)$ of decimal fractions. • Convert proper fractions, decimal fractions, terminating and repeating decimals, and % from one to another. • Rate, ratio, and proportion • ddd.dd $\times$ dd • ddd.dd $\div$ dd • ddd.dd $\times$ ddd • ddd.dd $\div$ ddd • All 4 operations $(+, -, \times, \div)$ of integers.	• Algebraic notation • Cancellation of equal values of chess pieces. • Counting in multi-direction with multiple attacks • Special tactics pattern • Chess pieces movements • Checkmate pattern • Attacking sequence • Interaction square • Logic

Comparison

Pattern and Relations (Patterns, Variable and Equations (grade 6 and above only), Measurement)

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grades K to 1	Identify, create, and compare patterns that arise from their daily experiences. Estimate, measure, and compare measures using whole numbers and non-standard units of measure.		• Compare length, size, area, weight, and volume. • Describe time and temperature	• The real distance and chess distance such as knight's move and promotion square and triangular moves of opposition.
Grade 2 to 3	Investigate, establish, and communicate rules that arise from daily and mathematical experiences, and use these rules to make predictions. Measure, estimate, and compare, using whole numbers and non-standard and standard units of measure.		• Measure length, mass, volume, and time. • Read and write time to the nearest minute using 12-hour notation. • Estimate, read, and record temperature to the nearest degree Celsius. • Count, write, and read money.	• The real distance and chess distance such as knight's move and promotion square and triangular moves of opposition.
Grade 4	Investigate, establish, and communicate rules for, and predictions from , numerical and non-numerical patterns. Estimate, measure, and compare quantities using numbers and standard units of measure.	• Algebraic notation	• Use grids, tables, charts, or calculators to explain mathematical relationships. • Measure objects in length, area, capacity, mass. • Read and write time on a 24-hour clock and a.m., p.m.	• The real distance and chess distance such as knight's move and promotion square and triangular moves of opposition.

Comparison

Pattern and Relations (Patterns, Variable and Equations (grade 6 and above only), Measurement)

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grade 5	Construct, extend, and summarize patterns, using rules, charts, mental mathematics, and calculators. Use measurement concepts, appropriate tools, and the results of measurements to solve problems in real-life contexts.		• Construct patterns in two or three dimension. • Explain the meaning of length, width, height, depth, thickness, perimeter, and circumference. • Solve problems in mass, perimeter, area, volume.	• Special tactics pattern • Chess pieces movements • Checkmate pattern
Grade 6	Use relationships to summarize, generalize, and extend patterns. Use informal and concrete representations of equality and operations on equality to solve problems. Be able to solve problems involving perimeter, area, surface area, volume, and angle measurement.	• Equal points of attacking pieces and defending pieces • Chess pieces points substitute chess symbols	• Solve one-variable equations with whole number coefficients. • Create expressions and rules to describe patterns and relationships of area, perimeter, volume etc. • Determine the perimeter of polygons. • Estimate angles using circular protractor. • Classify angles as acute, right, obtuse, straight, or reflex.	• Special tactics pattern • Chess pieces movements • Checkmate pattern • Inequality points of attacking pieces and defending pieces
Grade 7	Express patterns in terms of variables and use expressions containing variables to make predictions. Use variables and equations to express, summarize, and apply relationships as problem-solving tools in a restricted range of contexts. Solve problems involving the properties of circles and their relationships to angles and time zones.	• Equal points of attacking pieces and defending pieces • Chess pieces points substitute chess symbols • Angles formed by the movements of chess pieces.	• Solve and verify simple linear equations. • Substitute number variables • Write expressions. • Predict and justify the nth value of a number pattern. • Calculate time id different time zones. • Solve circumference, and area of a circle.	• Special tactics pattern • Chess pieces movements • Checkmate pattern • Inequality points of attacking pieces and defending pieces • Parallel and intersection of chess pieces.

Comparison

Shape and Space (3-D Objects and 2-D Shapes, Transformations)

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grades K to 1	Explore, sort, and classify real-world and three-dimensioned objects according to their properties.	• Square-shaped chessboard	• Identify circles, square, triangle, or rectangles. • Describe reflection	• Pattern of chessboard • Lines, shapes and patterns of the chess pieces on the chessboard.
Grade 2 to 3	Describe, classify, construct, and relate three-dimensional objects and two-dimensional shapes using common language to describe their properties.	• Bishop vs. parallel, checkmate vs. intersecting, rook vs. perpendicular.	• Describe faces, vertices, edges, sides, and angles of polygon and solids. • Name three-dimensional objects cubes, spheres, cones, cylinders, pyramids, and prisms. • Explore the concepts of points, lines, perpendicular lines, parallel lines, and intersecting lines on three-dimensional objects. • Graph whole numbers on a horizontal or a vertical number lines.	• Chess pieces moves in 360 degree. • Chess coordinates. • Lines, shapes and patterns of the chess pieces on the chessboard.
Grade 4	Describe, classify, construct, and relate three-dimensional objects and two-dimensional shapes using mathematical vocabulary to describe their properties.	• Bishop vs. parallel, checkmate vs. intersecting, rook vs. perpendicular. • Algebraic notation.	• Construct nets for pyramids and prisms. • Identify squares, rectangles, parallelograms, and trapezoids. • Draw point, line, parallel lines, and intersecting lines. • Place an object on a grid using columns and rows.	• Chess pieces moves in 360 degree. • Lines, shapes and patterns of the chess pieces on the chessboard.

Comparison

Shape and Space (3-D Objects and 2-D Shapes, Transformations)

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grade 5	Use the visualization of two-dimensional shapes and three-dimensional objects to solve problems related to spatial relation. Describe motion in terms of a slide, a turn, or a flip.	Chess coordinates – first quadrant only.	• Construct patterns in two or three dimension. • Explain the meaning of length, width, height, depth, thickness, perimeter, and circumference. • Solve problems in mass, perimeter, area, volume. • Classify triangles according to sides. • Classify polygons according sides of 3, 4, 5, 6, and 8. • Recognize translation, turn, or a flip, and tessellations • Identify point in the first quadrant using order pairs.	• Triangular move of opposition • Movement of the chess pieces on a 2-dimensional plane: how the Knight makes its tour on the chessboard touching each square only once. • In chess time, space and material interact in a "dynamic" or "flux" to create imbalances.
Grade 6	Use visualization and symmetry to solve problems involving classification and sketching. Create patterns and designs that incorporate symmetry, translations, tessellations, and reflections.	Chess coordinates – first quadrant only.	• Classify angles as acute, right, obtuse, straight, or reflex. • Classify triangles according to angles. • Regular polygons. • Draw solids on grids. • Draw slides, flips, and turns using grids to describe.	• Triangular move of opposition • Movement of the chess pieces on a 2-dimensional plane: how the Knight makes its tour on the chessboard touching each square only once. • In chess time, space and material interact in a "dynamic" or "flux" to create imbalances.
Grade 7	Link angle measurement to the properties of parallel lines. Create and analyze patterns and designs using congruence, symmetry, translation, rotation, and reflection.	Chess coordinates – first quadrant only.	• Complementary and supplementary angles. • Solve circumference, and area of a circle. • Angles related two parallel lines. • Construct angle bisectors and perpendicular bisectors. • Draw slides, flips, and turns using grids to describe in all quadrants.	• Triangular move of opposition • Movement of the chess pieces on a 2-dimensional plane: how the Knight makes its tour on the chessboard touching each square only once. • In chess time, space and material interact in a "dynamic" or "flux" to create imbalances.

Comparison

Statistics and probability (Data Analysis, Chance and Uncertainty)

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grades K to 1	Collect, organize, and analyze (with assistance) data based on first-hand information. Predict the chance of an event happening using the terms never, sometimes, and always.	• Chessboard • Make the next move using tree structure	• Construct a pictograph • Pose oral questions in relation to the data gathered.	• Number of possibilities of making the 1st move in chess.
Grade 2 to 3	Collect data based on first-and-second-hand information, display results in more than one way, interpret data, and make predictions. Use simple experiments designed by others to illustrate and explain probability and chance.	• Chessboard	• Display data in graphs, pictographs, bar graphs, and rank ordering. • Obtain information by performing arithmetic operations on the data. • Describe an outcome in terms such as likely, unlikely, fair chance, probable, and expected. • Conduct a probability experiment.	• Number of possibilities of making the 1st move in chess.
Grade 4	Collect first-and second-hand data, assess and validate the data-collection process, and graph the data. Conduct simple probability experiments to explain outcomes.	• Chessboard	• Construct bar graph and pictograph using many-to-one correspondence. • Identify an outcome in terms of possible, impossible, certain, uncertain. • Compare outcomes using terms equally, likely, more likely, or less likely.	• Number of possibilities of making the 1st move in chess.

Comparison

Statistics and probability (Data Analysis, Chance and Uncertainty)

Grades	Math Learning Outcomes	Matched chess knowledge to the math learning outcomes	Math knowledge learned not matched by chess	Math knowledge learned in chess but not included in math curriculum
Grade 5	Develop and implement a plan for the collection, display, and analysis of data gathered from appropriate samples. Predict outcomes, conduct experiments, and communicate the probability of single events.		• Distinguish between a population and sample. • Display frequency diagram, line plot, and broken-line plot. • Make inferences from the data to generate a conclusion. • Sample space • Use terms never/less likely/equally likely likely/more likely/always • Conduct probability experiments.	• Statistical analysis of opening moves that lead to wins for the white or black pieces. • Analysis of a given position in a chess database to evaluate possible moves. • Analyze combination of moves up to move 10.
Grade 6	Develop and implement a plan for the collection, display, and analysis of data gathered from appropriate samples. Use numbers to communicate the probability of single events from experiments and models.		• Justify sampling techniques. • Display data in histogram, double bar graphs, and stem and leaf plot. • Describe minimum, maximum, mode, median, and patterns. • Dice problems. • Distinguish experimental and theoretical probability of single events.	• Statistical analysis of opening moves that lead to wins for the white or black pieces. • Analysis of a given position in a chess database to evaluate possible moves. • Analyze combination of moves up to move 10.
Grade 7	Develop and implement a plan for the collection, display, and analysis of data, using measures of variability and central tendency. Create and solve problems using probability.		• Select and justify appropriate methods of collecting data. • Calculate mode, median, mean, range, extremes, gaps, quartiles, and clusters. • Interpolate from data to make predictions • Solve problems using the definition of probability as favorable outcomes over total outcomes.	• Statistical analysis of opening moves that lead to wins for the white or black pieces. • Analysis of a given position in a chess database to evaluate possible moves. • Analyze combination of moves up to move 10.

References

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(2) Chess and Standardized Test Scores, James Liptrap, Chess Life, March 1998. pp 41-43