Chess for Math Curriculum

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Background

A myriad education research papers have concluded that chess benefits children in many areas and one of the them is that it increases math scores (1, 2). This conclusion begs an inevitable question: how does chess seem to improve children's math scores? The most obvious reason one could probably think of is that there is a connection between chess and math, but how are math and chess connected? In addition, how are these connections actually linked to the school curriculum?

John Buky has outlined Chess curriculum aligned with the National Mathematics Standards (3). This article sets to find out the links between chess knowledge and school math curriculum learning outcomes. The other purpose of this article is to further evaluate how mathematical chess puzzles could reinforce math concepts learned and thus increases the potential of improving math ability. The process of play a good chess game is similar to the way of how to conduct critical thinking and problem solving, and this connection is well known so this article will not research the connection between chess and critical thinking skills.

A further exploratory question would be that if chess provides benefits in improving math ability then would it even more beneficial if children could actually work on some mathematical chess puzzles?

Method

A comparison is made between BC Ministry of Education mathematics Grades K to grade 7 Learning Outcomes and chess knowledge learned. The comparative results would show what chess knowledge learned would match the learning outcomes of BC Ministry of Education mathematics curriculum. This close relation demonstrated should provide strong evidence to the reason why chess improves math scores.

Comparison Summary and Observations

See Appendix A for details on comparison, below is a summary and observations.

Grades K to 4 represent the most challenging grades for chess teacher since there is abundant chess knowledge related to math but is not matched by math curriculum learning outcomes from grades K to 4. They are though, matched at higher grades from grade 5 to grade 7. However, when compared to higher grades, for the same reason these students from kindergarten to grade 4 are also the students who would benefit the most by learning chess with higher possibility of improving their math scores. The chess skills learned including algebraic notation, checkmate pattern and tactics pattern, how the chess pieces move and their respective values, could be transferred to math concepts.

By working on mathematical chess puzzles, students get training on how to transfer chess knowledge to improve math ability. Since chess is a whole number based strategy game so it is important for students get exposure to computational mathematical chess puzzles. Examples of mathematical chess puzzles incorporating math-learning outcomes from Grades K to grade 7 are included in this article.

Algebraic notation learned in chess could be transferred to the concept of coordinates, which are not introduced until grade 6. For this reason, lots of attention and practices must be given to students who are lower grade 6. When compared math learning outcomes and math knowledge learned in chess, chess is related to number operations, number concepts but students would benefit more if they are give the opportunities to work on integrated math and chess problems.

Chess patterns are very different from the math pattern problems in the sense that the chess pattern has cause-consequence effect and do not use the relation of the adjacent terms to predict the next term. The chess tactics and checkmate patterns use special formation to jointly produce its result(s). The most interesting is one would not learn this kind of pattern other than by playing chess.

The king's triangular shape of movement to create opposition in chess is an example on how the use of a geometric shape would take a special meaning in chess. How about the distance in knight moves? It may take less moves for a knight to reach a far away square than to a nearby square. The diagonal distance is the same as the side length of a square when promoting a pawn, all these are very intriguing when thinking from math's point of view. These have to be clearly explained to elementary students. See examples in this article for more explanations.

One notable math knowledge learned in playing chess but not widely taught is the set theory. Chess players constantly use the concept of Venn diagram to look for interactions among chess pieces. Chess game itself it is highly related to data gathering and information analysis, its relation to statistics and probability could be highlighted by working on math and chess puzzles.

The effect of transferring math knowledge learned in chess will be less significant if the chess teacher does not take the efforts to emphatically point out the math concepts. The task of transferring math knowledge leaned in playing chess would be much easier if students are offered the opportunities to work on mathematical chess puzzles.

Many children could not play chess well but feel very proud that they could solve mathematical chess puzzles. Mathematical chess puzzles provide some children additional opportunities that they could challenge themselves. For this reason, I give prizes to chess winners and also to puzzles solvers.

The most interesting about using chess symbols is that the chess symbols themselves not only possess pre-defined values but also have the implied meaning of movements and these two special characters allow me to create some very interesting mathematical puzzles with pizzazz.

By using chess symbols, a simple one-step arithmetic problem could become a multi-step problem, as this result, chess symbols and values offer children more opportunities to work on another type of questions which could simulate children’s brain cell and improve their problem-solving ability. So the benefits of working on these types of problems is double edged- improving chess knowledge and also mathematical problem-solving ability.

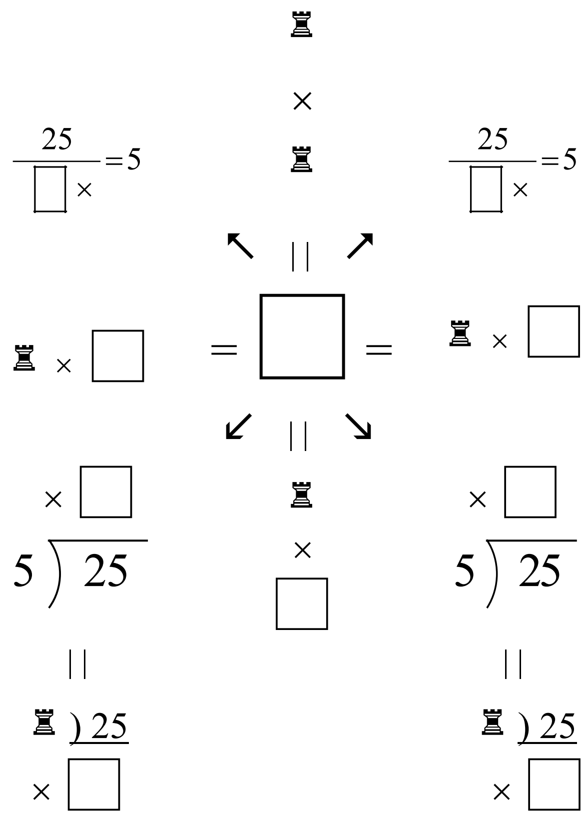
Example 1 - Number Concepts and Operations: Addition and Subtraction

The following problem is designed to be different from traditional worksheets, which are always from left to right or top to down in linear fashion. One could work out the problem below from the bottom to top and then from top to down in multi-direction. It uses chess symbol as part of computation, thus multi-step problems are created.

Bottom/up and top/down operation	Bottom/up and top/down operation
□ 12 − ♝ + ♝ □ ♛	□ □ − ♜ + ♜ 6 6

Example 2 - Number Concepts and Operations: Multiplication of doubling

The following problem is created with the mind that children do not really learn math in a sequential way of addition, subtraction, multiplication, or division in real life. This example demonstrates times table created using different formats. A simple multiplication problem is changed to a problem in multi-direction, multi-operation, multi-step, and multi-concept learning.



Example 3 - Number Concepts and Operations: Addition and Subtraction, If Then - Else

The following operation takes a circular motion in clockwise.

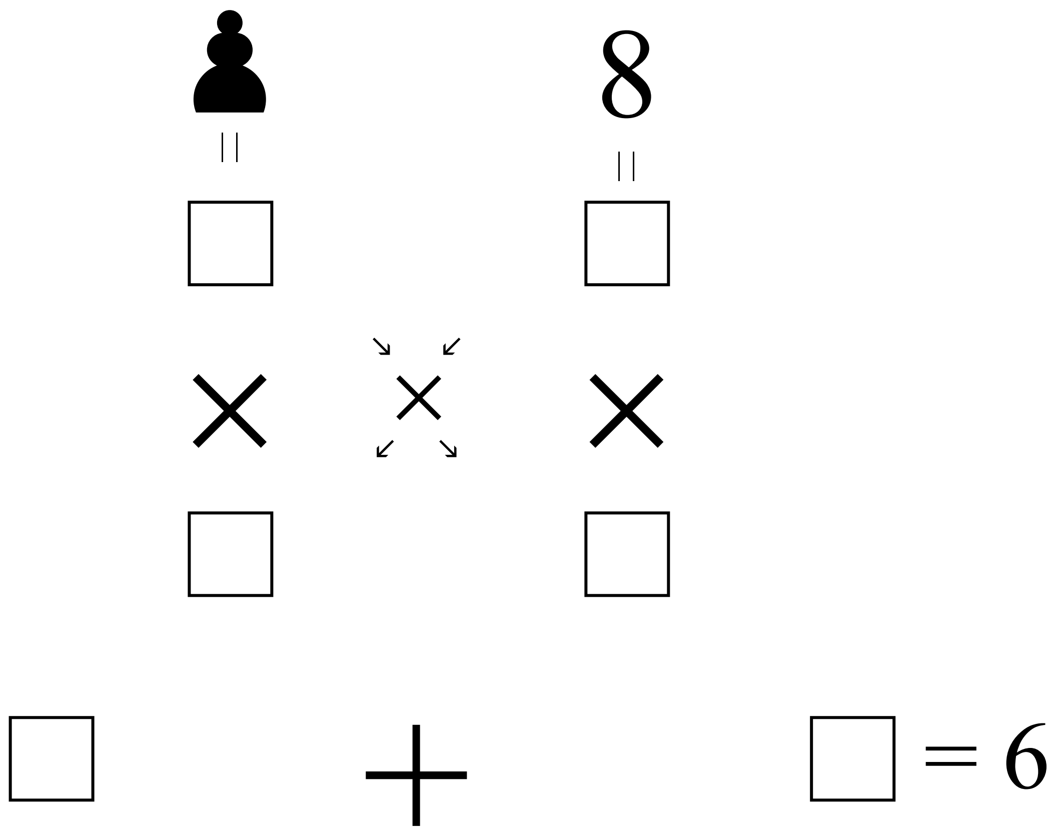
19	−	♚	=	□	
9	+	♚	=	□	+
+ □				□	

If 10 + ♜ = □, then 9 + ♜ must be □.

If ♜ + 10 = □, then ♜ + 9 must be □.

Example 4 - Number Concepts and Operations: Cross Multiplication

A five-step question which could be used a method to do factoring in grade 9.



Example 5 - Number Concepts and Operations: Multiplication and Division

Will the following operations cause confusion to children? The answer is no. ♛×♞ will not make sense if it is explained literally as a queen times a knight. However if it is translated into numerals 9 times 3 then the product must be 27 which is very logic and children understand that they are working on the product of 9 × 5, not the product of ♛×♞.

A similar type of logic question is as follows: If 2 # 3 is defined as 2 + 2 × 3 then what is 3 # 4? Normally 2 # 3 will not make any sense since it is not a valid arithmetic operator but if we define it clearly then it becomes workable.

♛ × 2 18 ÷ 2 = □	♛ × ♜ □ ÷ 5 = □
♛ × ♜ □ ÷ 9 = □	♛ × ♛ □ ÷ ♛ = □
♛ × ♞ □ ÷ ♞ = □	♛ × ♞ □ ÷ ♛ = □

Example 6 – Pattern and Relations: Equation

The following example demonstrates how chess symbols and chess values are integrated with arithmetic operations.

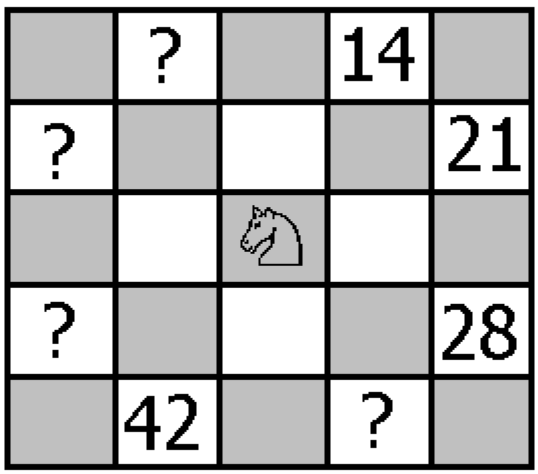
♛ + ♞ + x = 54 x = ______

Example 7 – Pattern and Relations: Pattern

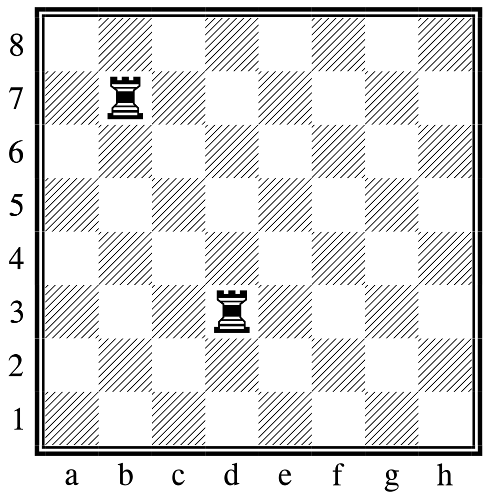
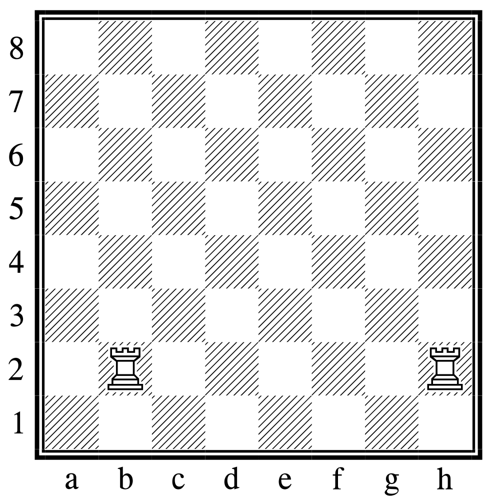
Chess pieces can move horizontally, vertically or diagonally and the concept of symmetry is not in the learning outcome of grade K to 1, so they must thoroughly explained to students. An example of math and chess integrated puzzle using chess move is as follows.

Use chess moves to solve the following puzzle.

On the first look, lots of students are not able to solve it, why? Students are so used to do computation from left to right and this question has to be solved in an unconventional direction. Chess is a 360^0 Visualization game and this example demonstrates how knight move would help solve this puzzle.



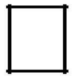
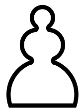
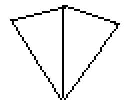
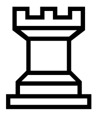
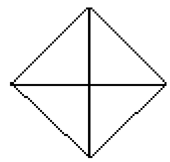
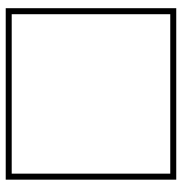
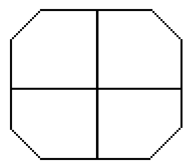
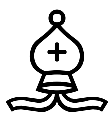
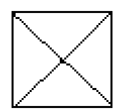
Example 8 Set Theory shown by two-column format

Cross mark (✕) the square(s) where all rooks could share the common squares. 	Find the common factors of the following numbers. 12, 24 13, 26
Cross mark (✕) the square(s) where all rooks could share the common squares. 	Find the common factors of the following numbers. 11, 121 3, 26

Example 9 An example using chess moves

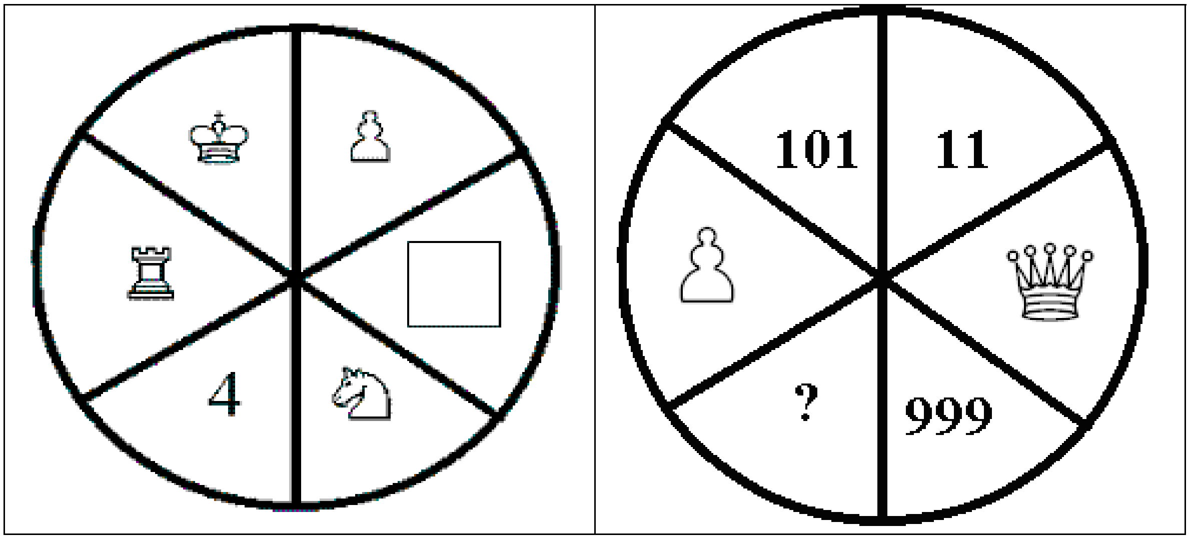
If ♛ ÷ ♝ = ♜
Then what is ♚ ÷ ♜ =?

Example 10 Shape and Space - The following is a puzzle that requires the knowledge of chess moves.

Filling in  by a chess piece	Geometric shapes
	
	
	
	

Example 11 – Pattern and Relations

Find values to replace? or fill in □. An example using chess pieces values and logic.



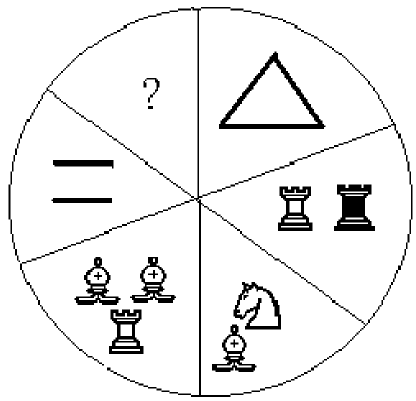
Example 12 - Use chess symbol moves to solve the following puzzle.

If 2 ♜ 3 = 5 then 2 ♝ 3 is = ____

Surprisingly, some of my students have no trouble to solve the above puzzle.

Example 13 – Shape and Space

Use chess symbol moves to solve the following puzzle.



Example 14 - Statistics and Probability

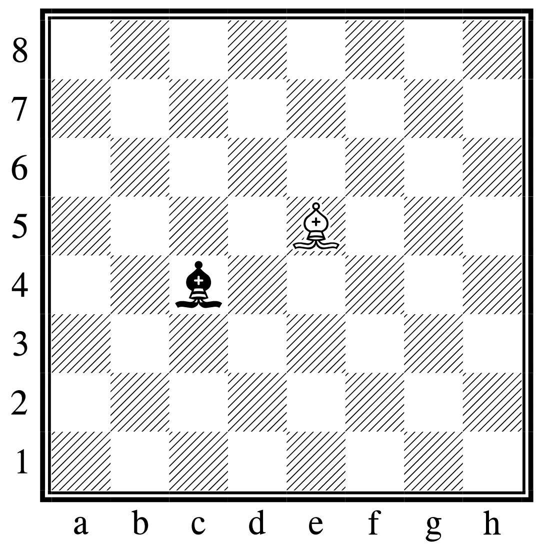
Table Values

The use of chess values is much like the use of monetary values. When chess or money figures are seen by children, they both represent some pre-defined meaningful values. The following is an example where the values of chess pieces could be monetary values and ”Total Points” could be the sum of total money.

Fill in the different number of chess pieces to come up with each total.

Number of ♟	Number of ♞	Number of ♜	Total points
1	1	1	9
3	2	0	9
0	3	0	9
☐	☐	☐	10
☐	☐	☐	10
☐	☐	☐	11
☐	☐	☐	12
☐	☐	☐	13
☐	☐	☐	14
☐	☐	☐	15

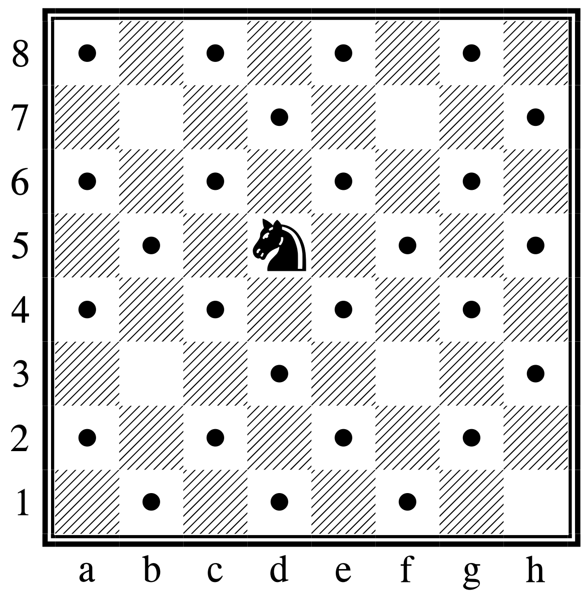
Example 15 - Statistics and Probability

Chess Puzzle Samples	Expected Math Learning Outcomes	Chess knowledge required
What is the probability of the following two pieces meeting together? 	▪ Probability	▪ Chess pieces moves

Example 16 - How does knight move?

How does knight move?

Move the knight at d5 to each square identified by ⊡. For example, it will take 2 moves from d5 to move to b5. Nd5 – c7 – b5. Write the least number of moves required to reach each ⊡ from Nd5 on the squares of ⊡..



When 2 is not = 2?

Observe your results and see if all your answers are 2's?

Answer: ________________.

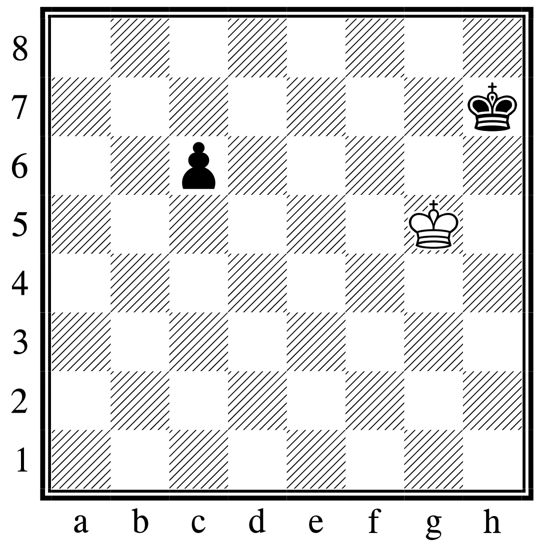
If each move is identified as 1 and 2 moves is 2 then you would see that in chess the meaning of "move" takes a different meaning since not all 2-move have the equal distance from d 5. For example, it takes knight 2 equal moves from d5 to b5 and from d5 to a4, yet physically a4 is farther away from d5 than b5.

How many moves does it take for the knight at d5 to move to the 5 White squares not identified by ⊡ on the left side diagram?

Answer: ________________________

Example 17 Diagonal length = Side length

Is the distance from c6 to c8 the same as distance c6 to a8?



Example 18 - Pattern and Relations

The following problem demonstrates that not only children will not get confused on traditional chess symbols used in arithmetic expression, they could be led to use additional “creative” chess symbols and are able to solve them correctly. This problem is suitable to grade 3 and above students.

Chess Symbol	Logic Training
A new Chess Symbol is defined as follows:	In the following equation, observe the chess symbols on the left and fill in each ◯ with a number.

Chess figurines	Chess symbols
♔	÷ (Opposition)
♖	+
♘	L
♗	×
♕	✳
♙	⩛

If + + + = 10

then ÷ + + = ◯

```
    + ✳
+   + ÷
-------
  ◯ ÷ ✳
```

Use the above Chess Symbol table, find the following pattern:

Z, ÷, O, ⩛, T, L, T, ×, F, +, _____, ✳

Use the above Chess Symbol table, find the following pattern:

0, ÷, 1, ⩛, ___, L, 3, ×, 5, +, ___, ✳

Reference

(1) Chess $ Math Add Up, Yee Wang Fung, Teacher, May/June, 1995
(2) Chess and Standardized Test Scores, James Liptrap, Chess Life, March 19998
(3) Chess curriculum aligned with the National Mathematics Standards, unpublished manuscript, John Buky, 2005