

**SEQUENCING OF THE ELEMENTARY CONCEPTS OF SQUARE AND SQUARE ROOTS & IDENTIFYING THESE ARE USED IN M.P., I.C.S.E. EXAMINATION AND S.C.E.**

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*(Received On: 14-09-15; Revised & Accepted On: 13-10-15)*

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**ABSTRACT**

*In this paper, total identified 52 elementary concepts of the major concept square and square roots have been sequenced and presented here. This work was done by 'text book scanning process', 'task analysis technique' and incorporating 'experts' opinions'. Here, It is also identified the elementary concepts which were used to solve the arithmetical problems of mathematics question papers of 10<sup>th</sup> standard of Madhyamik Pariksha (M.P.) (1999, 2000) of West Bengal Board of Secondary Education (W.B.B.S.E.), Indian Certificate of Secondary Education (I.C.S.E.) Examination (2005, 2006) of the Council for the Indian School Certificate Examinations (C.I.S.C.E.), School Certificate Examination (S.C.E.) (1999, 2000) of Visva-Bharati (a Central University). This study will help the entire curriculum development of school mathematics.*

**Key Words:** *major concepts, elementary concepts, Identifying, sequencing, square and square roots, text book scanning process, task analysis technique.*

**MSC: AMS Subject Classification 2010:** 97C99, 97D99, 97F99.

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**1. INTRODUCTION**

In the present day school curriculum, considering the importance of the subject mathematics in respect of nurturing the rational mind of human being, it has a beautiful flavor for its nature of abstraction, this has a great impact in the modern science based civilization; it has been made a compulsory school subject in almost all countries in the world. But it is real fact that a large number of learners feel uneasy to learn the subject for improper presentation of the content. If there is any conceptual gap in the content presentation that will be very harmful for the learners, even a phobia towards mathematics may be created among them. So the author has done some works on this area (24, 26). He has also identified 52 elementary concepts of square and square roots which were not presented in (25). In this paper, all these elementary concepts of square and square roots have been presented sequentially and at the same time which concepts were used to solve the arithmetical problems of mathematics question papers of M.P. (1999 & 2000), I.C.S.E Examination (2005 & 2006) and S.C.E. (1999 & 2000) have been identified considering the curriculum development of the subject.

**2. OBJECTIVE OF THE STUDY**

- (i) The objective of the study is to present identified different elementary concepts and their sequential order of square and square roots.
- (ii) To identify the elementary concepts of square and square roots which were used to solve the arithmetical problems of M.P (1999 & 2000), I.C.S.E Examination (2005 & 2006) and S.C.E. (1999 & 2000).

**3. DEFINITIONS**

**3.1 Major concept and Sub-concepts:**

A Major concept is an idea which is complete in itself and is comprehended through a sequential process of step-by-step partial comprehension of its related concepts. These related concepts are called sub-concepts which are not complete in itself but are parts of the major concept.

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Examples of major concepts are ‘addition of whole numbers including the familiarity of the numbers’, ‘subtraction of whole numbers’, ‘measurement of mass’, ‘fraction’, ‘decimal’, ‘rational number’ etc.

For the major concept such as ‘Addition of whole numbers including the familiarity of the numbers’, its sub-concepts are ‘addition of one-digit numbers including zero where the sum is one-digit number’, ‘addition of one-digit numbers where the sum is two-digit number’ etc.

### **3.2 First level sub-concepts:**

The sub-concepts which are obtained after immediate derivation of a major concept are called first level sub-concepts.

### **3.3 Second level sub-concepts and others:**

When the derivation of first level sub-concepts are continued, the other sub-concepts so obtained stage by stage are called second level, third level etc.

### **3.4 Elementary concept:**

A sub-concept which can not be split further will be called an ‘elementary concept’.

## **4. MATERIALS AND METHODS**

Procedure adopted has been discussed below:

### **4.1 Collection of text books:**

The prescribed text books of mathematics from Class-1 to 10 of West Bengal Board of Primary Education (W.B.B.P.E.), W.B.B.S.E., National Council of Educational Research and Training (N.C.E.R.T.) and other available books from the market were collected in the first stage (1-23).

### **4.2 Analysis of text books:**

These books were analyzed to identify square and square roots as a major concept and their elementary concepts of arithmetic mainly.

### **4.3 Task analysis of question papers:**

In the identification and sequencing of basic concepts, task analysis technique has also been applied on arithmetical problems of mathematics question papers of 10<sup>th</sup> standard of M.P. (1999, 2000) of W.B.B.S.E., I.C.S.E. Examination (2005, 2006) of C.I.S.C.E., S.C.E. (1999, 2000) of Visva-Bharati (a Central University).

### **4.4 Sequencing of concepts:**

The identified major concept and their elementary concepts were sequenced keeping in view the logical order of the subject and the psychological order of learners.

### **4.5 Experts’ opinions:**

The major concept and their elementary concepts with examples were given to experts for their comments. The experts were requested to add or omit or alter the sequence of concepts as they felt necessary.

Finally, the sequential form of elementary concepts of the major concept square and square roots incorporating the experts’ opinion was developed.

### **4.6 Identifying used elementary concepts:**

The elementary concepts of square and square roots used to solve the arithmetical problems which had been done at 4.3 Task analysis of question paper were identified.

## **5. SALIENT POINTS OF THE STUDY**

The major concept: square and square roots has been divided into three first level sub-concepts which are expressed in tabular form in Table-1. Each first level sub-concept has been divided into different sub-concepts. Total identified 52 elementary concepts have been sequenced. The splitting of sub-concepts is continued through different levels until elementary concepts are reached. In this investigation each sub-concept is numbered with a position value of different levels i.e. when a sub-concept is denoted by i.j.k...., then i indicates the first level sub-concept no., j indicates the second level sub-concept no., k indicates the third level sub-concept no. etc. The numbers of different elementary concepts of the each first level sub-concept are shown in Table-2.

**Table-1:** List of first level sub-concept of Square and square roots

Sl. No.	First level sub-concept
1.	Square number
2.	Square root of whole number (perfect square)
3.	Square root of vulgar fraction and decimal fraction

**Table-2:** Detailed list of different levels of sub-concepts of the major concept: Square and square roots

1	2	3	4	5	6
First level sub-concept sl. Nos.	Number of second level sub-concept	Number of third level sub-concept	Number of fourth level sub-concept	Number of fifth level sub-concept	Total number of elementary concepts
1.	5	1+1+8+2+1	1+1+14+2+1	—	19
2.	5	1+5+1+2+2	1+5+1+3+5	—	15
3.	8	2+2+2+2+1+1+1+1	4+3+2+2 +1+1+1+1	6+4+2+2+1+1+1+1	18
				<b>Grand Total</b>	<b>52</b>

The process of detailing out of first level sub-concepts has been done. Here, total identified 52 elementary concepts have been presented. In the presentation, some of the elementary concepts of the sub-concepts have been elaborated giving question (Q) for better clarification and rest of the elementary concepts have only been presented for due to economy of space.

Here ‘\*’ represent the concepts which had been introduced in the prescribed text books of W.B.B.S.E. & N.C.E.R.T. both

‘\*\*’ represent the concepts which had been introduced in the prescribed text books of N.C.E.R.T. only but not in W.B.B.S.E.

‘\*\*\*’ represent the concepts which had been introduced in the prescribed text books of W.B.B.S.E. only but not in N.C.E.R.T.

‘\*\*\*\*’ represent the concepts which had not been introduced in the prescribed text books of W.B.B.S.E. & N.C.E.R.T.

**The second level sub-concepts of sub-concept no. 1:** Square number.

1.1 Definition of square. (\*)

Q. Fill in the blank.

The square of a number is that number raised to the power\_\_\_\_\_.

1.2 Definition of perfect square or a square number. (\*)

Q. Find the square of 15.

1.3 Properties of some square numbers.

1.4 Alternate methods of squaring numbers.

1.5 Problems involving perfect square. (\*\*)

Q. Is 2352 a perfect square?

**The third level sub-concepts of sub-concept no. 1.3:** Properties of some square numbers.

1.3.1 No square numbers ends 2, 3, 7, 8. (\*)

1.3.2 Given the units digits of a number, determining the units digits of its square. (\*)

1.3.3 The number of zeros at the end of a perfect square is always even. (\*)

Q. The following number is not a square number, give reason.

64000

1.3.4 If a number is even (odd), then so is its square. (\*)

1.3.5 A perfect square number leaves a remainder 0 or 1 on division by 3. (\*)

Q. Show that the following number is not perfect square.

1058

1.3.6 The list of possible remainders in 1.3.5 above can be helpful when a number is not a perfect square. (\*)

1.3.7 If n is a perfect square, then 2n can never be a perfect square. (\*)

1.3.8 Pattern of some square numbers.

**The fourth level sub-concepts of sub-concept no. 1.3.8:** Pattern of some square numbers.

1.3.8.1 The squares of numbers like 1, 11, 111, ... etc, which are composed of digit 1 alone, have a nice pattern as shown below:

$$1^2=1$$

$$11^2=121$$

$$111^2=12321$$

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$$111111111^2=12345678987654321 \quad (**)$$

1.3.8.2 Pattern related to squares of numbers.

$$1^2=1$$

$$11^2=121 \text{ and } 1+2+1=2^2$$

$$111^2=12321 \text{ and } 1+2+3+2+1=3^2$$

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$$111111111^2=12345678987654321 \text{ and } 1+2+3+4+\dots+5+4+3+2+1=9^2 \quad (**)$$

1.3.8.3 Pattern related to squares of numbers.

$$121 \times (1+2+1)=484=22^2$$

$$12321 \times (1+2+3+2+1)=110889=333^2$$

$$\text{i.e. } 11^2 \times (\text{sum of digits of } 11^2)=22^2$$

$$111^2 \times (\text{sum of digits of } 111^2)=333^2 \quad (**)$$

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$$111111111^2 \times (\text{sum of digits of } 111111111^2)=999999999^2$$

$$1.3.8.4 \text{ For every natural number } a, \text{ we have } a^2 + (a+1)^2 + \{a(a+1)\}^2 = \{a(a+1)+1\}^2 \quad (**)$$

1.3.8.5 Pattern related to squares of numbers.

$$25^2=2 \times (2+1) \text{ hundred} + 25=625$$

$$45^2=4 \times (4+1) \text{ hundred} + 25=2025$$

$$115^2=11 \times (11+1) \text{ hundred} + 25=13225 \quad (**)$$

Q. Using this pattern, find the square of 35.

1.3.8.6 Pattern related to squares of numbers.

$$52^2=(5^2+2) \text{ hundred} + 2^2=2704$$

$$57^2=(5^2+7) \text{ hundred} + 7^2=3249 \quad (**)$$

Q. Using this pattern, find the square of 51.

1.3.8.7 Pattern related to squares of numbers.

$$511^2=(250+11) \text{ thousand} + 11^2=261121$$

$$590^2=(250+90) \text{ thousand} + 90^2=348100$$

Q. Using this pattern, find the square of 509. (\*\*)

**The third level sub-concepts of sub-concept no. 1.4:** Alternate methods of squaring numbers.

1.4.1 Finding the squares using column method and verify the result using usual method. (\*\*)

Q. Find the square using column method and verify the result using usual method.

25

1.4.2 Finding the squares using diagonal method and verify the result using usual method. (\*\*)

Q. Find the square of the following number using diagonal method and verify the result using usual method.

79

**The second level sub-concepts of sub-concept no. 2:** Square root of whole number (perfect square).

2.1 Concept of square root and its symbol. (\*)

Q. Guess and verify the square root of 25.

2.2 Properties of square root of whole number.

2.3 Finding square root of whole number (perfect square) using repeated subtraction. (\*\*)

Q. Find the square root of 49 by repeated subtraction.

2.4 Determination square root of whole number (perfect square) using method of factorization.

2.5 Finding square root of whole number (perfect square) using method of division.

**The third level sub-concepts of sub-concept no. 2.2:** Properties of square root of whole number.

2.2.1 If the units digit of a number is 2, 3, 7 or 8, then it is not a perfect square and hence does not have a square root.

(\*)

2.2.2 If a number has a square root, then its units digit must be 0, 1, 4, 5, 6 or 9. (\*)

2.2.3 If a number ends in an odd number of zeros, then it does not have a square root. If a square number is followed by an even number of zeros, it has a square root. (\*)

2.2.4 The square root of an even square number is even and the square root of an odd square number is odd. (\*)

2.2.5 Negative numbers are not perfect squares and, therefore, have no square root in the system of rational numbers.

(\*)

**The third level sub-concepts of sub-concept no. 2.4:** Determination square root of whole number (perfect square) using method of factorization.

2.4.1 To determine square root. (\*)

Q. Find the square root of the following by means of factors.

64

2.4.2 Problems involving square root.

**The fourth level sub-concepts of sub-concept no. 2.4.2:** Problems involving square root.

2.4.2.1 Solution of the given problem and writing proper answer. (\*)

Q. The students of class VII of a school donated Rs 3481 for Prime Minister's National Relief fund. Each student donated as many rupees as the number of students in the class. Find the number of students in the class? (Use the method of factorization)

2.4.2.2 Formation of the problem and working out its solution. (\*\*\*\*)

Q. Make a problem involving square root of whole number (perfect square) and then solve it using method of factorization.

**The third level sub-concepts of sub-concept no. 2.5:** Finding square root of whole number (perfect square) using method of division.

2.5.1 Finding square root.

2.5.2 Problems involving square root.

**The fourth level sub-concepts of sub-concept no. 2.5.1:** Finding square root.

2.5.1.1 Finding the number of digits in the square root of each of the whole numbers without actually finding its square root. (\*)

Q. Find the number of digits in the square root of the following number using method of division.  
657666025

2.5.1.2 Finding the digits in the units' place of square roots of the whole numbers. (\*)

Q. What may be the digit in the unit's place of the square root of the following numbers?(use the method of division)  
5329

2.5.1.3 Finding square root. (\*)

Q. Find the square root of 529 using method of division.

**The fourth level sub-concepts of sub-concept no. 2.5.2:** Problems involving square root.

2.5.2.1 Solution of the given problem and writing proper answer. (\*)

Q. Find the least number that must be subtracted from 893304 so as to get a perfect square using method of division.

2.5.2.2 Formation of the problem and working out its solution. (\*\*\*\*)

Q. Make a problem involving square root of whole number (perfect square) and then solve it using method of division.

**The second level sub-concepts of sub-concept no. 3:** Square root of vulgar fraction and decimal fraction.

3.1 Square root of perfect vulgar fraction.

3.2 Square root of perfect decimal fraction.

3.3 Square root of non-perfect square whole number up to certain decimal places.

3.4 Square root of non-perfect square vulgar fraction up to certain decimal places.

3.5 Square root of non-perfect square decimal fraction up to certain decimal places. (\*)

Q. Find square root of the following decimal (correct up to three decimal places).  
0.4

3.6 Square root of a rational number. (\*)

Q. Find the square root of  $\frac{1}{4}$ .

3.7 Square root of 2. (\*)

Q. Find the square root of 2.

3.8 Finding the greatest and lowest number involving square root. (\*)

Q. Write down the greatest and the least number.

0.16,  $\sqrt{0.16}$ ,  $(0.16)^2$ ,  $0.1\dot{6}$

**The third level sub-concepts of sub-concept no. 3.1:** Square root of perfect vulgar fraction.

3.1.1 Using method of factorization.

3.1.2 Using method of division.

**The fourth level sub-concepts of sub-concept no. 3.1.1:** Using method of factorization.

3.1.1.1 Finding square root of perfect vulgar fraction. (\*)

Q. Find the square root of  $\frac{361}{625}$  using method of factorization.

3.1.1.2 Problems involving square root of perfect vulgar fraction.

**The fifth level sub-concepts of sub-concept no. 3.1.1.2:** Problems involving square root of perfect vulgar fraction.

3.1.1.2.1 Solution of the given problem and writing proper answer. (\*\*\*)

Q. Solve the following problem using method of factorization.

By which number multiplied to the square root of  $\frac{625}{144}$  that the product will be 1?

3.1.1.2.2 Formation of the problem and working out its solution. (\*\*\*)

Q. Make a problem involving square root of perfect vulgar fraction and solve it using method of factorization.

**The fourth level sub-concepts of sub-concept no. 3.1.2:** Using method of division.

3.1.2.1 Finding square root of perfect vulgar fraction. (\*)

Q. Find square root of  $\frac{225}{3136}$  using method of division.

3.1.2.2 Problems involving square root of perfect vulgar fraction.

**The fifth level sub-concepts of sub-concept no. 3.1.2.2:** Problems involving square root of perfect vulgar fraction.

3.1.2.2.1 Solution of the given problem and writing proper answer. (\*\*\*)

Q. Solve the following problem using method of division.

By which number multiplied to the square root of  $\frac{625}{144}$  that the product will be 1?

3.1.2.2.2 Formation of the problem and working out its solution. (\*\*\*)

Q. Make a problem involving square root of perfect vulgar fraction and solve it using method of division.

**The third level sub-concepts of sub-concept no. 3.2:** Square root of perfect decimal fraction.

3.2.1 Finding square root of decimal fraction after expressing a decimal fraction as a vulgar fraction. (\*)

Q. Find the square root of 0.0196.

3.2.2 Finding square root of decimal fraction using method of division.

**The fourth level sub-concepts of sub-concept no. 3.2.2:** Finding square root of decimal fraction using method of division.

3.2.2.1 Finding square root of decimal fraction. (\*)

Q. Find the square root of 0.000324 using method of division.

3.2.2.2 Problems involving square root of decimal fraction.

**The fifth level sub-concepts of sub-concept no. 3.2.2.2:** Problems involving square root of decimal fraction.

3.2.2.2.1 Solution of the given problem and writing proper answer. (\*\*\*)

Q. Solve the following decimal number using method of division.

Which decimal number is multiplied by the same number that the product will be 1.1025?

3.2.2.2.2 Formation of the problem and working out its solution. (\*\*\*\*)

Make a problem involving square root of decimal fraction and solve it using method of division.

**The third level sub-concepts of sub-concept no. 3.3:** Square root of a non-perfect square whole number up to certain decimal places.

3.3.1 Concept of square root of non-perfect square whole number. (\*)

Q. Which numbers are the non-perfect square numbers of the following numbers?

$$5, 16, \frac{1}{7}, \frac{4}{25}$$

3.3.2 Finding the square root of a non-perfect square whole number. (\*)

Q. Find the square root of 5.

**The third level sub-concepts of sub-concept no. 3.4:** Square root of non-perfect square vulgar fraction up to certain decimal places.

3.4.1 Finding the square root of a non-perfect square vulgar fraction after expressing the vulgar fraction as the decimal fraction. (\*)

Q. Find the square root of  $11\frac{2}{3}$  correct to two places of decimal.

3.4.2 Finding the square root of a non-perfect square vulgar fraction after the denominator should always be made a perfect square. (\*)

Q. Find the square root of  $10\frac{2}{3}$  after transform the denominator as a perfect square.

Now, the elementary concepts among the above presented 52 elementary concepts of square and square roots were used in M.P.(1999 & 2000), I.C.S.E. Examination (2005 & 2006) and S.C.E. (1999 & 2000) have been identified and their frequency of use are counted which are shown below in Table-3.

**Table-3:** List of Elementary concepts of square and square roots used in M.P., I.C.S.E. Examination and S.C.E.

1	2	3	4	5	6
M.P. (1999 & 2000)		I.C.S.E. Examination (2005 & 2006)		S.C.E. (1999 & 2000)	
Elementary concept no.	Frequency of use	Elementary concept no.	Frequency of use	Elementary concept no.	Frequency of use
1.2	6	3.3.2	2	Nil	Nil
1.5	1				
2.4.1	2				
2.5.1.3	2				
3.2.1	1				
3.2.2.1	1				
3.8	1				
<b>Total</b>	<b>14</b>				

From the above presentation of the elementary concepts and the presentation of Table-3, it is clear that the elementary concept no. 1.5 used in M.P. but it was not introduced in the prescribed text books of mathematics of W.B.B.S.E.



## 6. CONCLUSION

- (i) This methodology will help to mark different types of conceptual gaps of mathematics in the syllabus, text books and entire teaching learning process.
- (ii) Total 52 identified elementary concepts of square and square roots have been sequenced and presented here. Total 36 elementary concepts out of 52 had been taken into consideration in the prescribed text books of mathematics of W.B.B.S.E. whereas N.C.E.R.T.'s text books had considered 44 elementary concepts which have been presented in the salient points of the study.
- (iii) Table-3 reveals that total 7 elementary concepts (1.2, 1.5, 2.4.1, 2.5.1.3, 3.2.1, 3.2.2.1, 3.8) of square and square roots and their total frequency of use is 14 have been used to solve the arithmetical problems of mathematics question papers of M.P. (1999 & 2000) but to solve the arithmetical problems of I.C.S.E. Examination's mathematics question papers (2005 & 2006) only 1 elementary concept and its frequency of use is 2 was needed. But no elementary concept of square and square roots was used for S.C.E. (1999 & 2000).
- (iv) The elementary concept 1.5: Problems involving perfect square was used to solve the arithmetical problem of mathematics of M.P. but it is a matter of pity that this concept was not introduced in the prescribed text books of mathematics of W.B.B.S.E. So, it should be included in the prescribed text book.
- (v) It will also help to diagnose the particular areas of weakness of learners and also in planning for necessary remedial measures.
- (vi) Backward learners can be detected easily and remedial method for them can be applied.
- (vii) This study will help sequentially to develop the activities of square and square roots for better understanding of learners.
- (viii) Special interest for mathematics can be enhanced which will be helpful for entire science education.

## 7. FURTHER STUDY

- (i) To undertake diagnostic study on large number of samples of classes-VII, VIII on 'square and square roots'.

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**Source of support: Nil, Conflict of interest: None Declared**

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