Identifying the Elementary Concepts of Algebra and Their Rank Orders Used in I.C.S.E. Examination

Research Article

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Abstract: In this paper, an attempt has been made to identify top forty four elementary concepts of algebra and their rank orders which were used to solve the mathematical problems of two question papers of mathematics of Indian Certificate of Secondary Education (I.C.S.E.) Examination (2005 & 2006) of The Council for the Indian School Certificate Examination (C.I.S.C.E.) through task analysis technique. This study has emphasized to remove the conceptual gaps in mathematics text books. The teachers as well as learners will be benefited in several ways like to diagnose the weakness of the learners, to find the difficult order of these concepts, to emphasize on the learning of these concepts at appropriate grade levels etc. after knowing these elementary concepts.

MSC: 97C99, 97H10.

Keywords: Identifying, major concept, elementary concept, algebra, text book scanning process, task analysis technique, mathematics question papers.

1. Introduction

Mathematics is such a subject which is the root of the modern civilization. For that, this subject has been made compulsory up to 10 class of schooling in almost all countries of the world including India. But the concept achievement level of students in mathematics varies from one student to other, one school to other even one country to other.

In India, present teaching-learning status of the subject is not cheering up. Many factors are responsible for this unwanted situation. It is known that learners can solve several problems if they are acquainted those elementary concepts which are used to solve the same. Therefore learners have to acquire the knowledge of some basic mathematical concepts. Author has done some works on identification and sequencing the elementary concepts of different major concepts of arithmetic and algebra (Please see reference from 15 to 56). He has identified 1253 elementary concepts of algebra through the 'text book scanning process' (Please see reference from 1 to 14, 58 to 66) and 'task analysis technique'. On the other hand, it is important to know those elementary concepts which are needed to solve the problems of algebra and arithmetic of mathematics question papers of the different Boards. Because, if the students are masters on these elementary concepts, these competencies of the learners will then help to solve the algebraic problems and arithmetical problems where the algebraic method may be used of the Board examination. So, the author has emphasized to identify the elementary concepts of algebra which are used to solve the problems of mathematics of I.C.S.E. Examinations and has already identified top thirty elementary concepts (57) of them.

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In this paper, a searching has been undertaken to identify most frequently used forty four algebraic elementary concepts and their rank orders to solve the algebra group problem of mathematics of I.C.S.E. Examinations (2005 & 2006) through task analysis technique.

2.   Objective of the Study

To identify the top forty four elementary concepts of algebra and their rank orders used in Indian Certificate of Secondary Education (I.C.S.E.) Examination (2005 & 2006) of The Council for the Indian School Certificate Examination (C.I.S.C.E.).

3.   Definitions

3.1.   Major Concepts 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.

3.2.   Elementary Concepts

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

4.   Materials and Methods

It has been done in several stages

(i). The two years question papers of mathematics I.C.S.E Examination (2005 & 2006) have been collected for studying the major concepts of mathematics at secondary level through the task analysis technique.

(ii). All the items of arithmetic and algebra which are relevant to our major concept analysis of the said question papers have been solved in such a way that a student may get full mark on each item. All the methods have been considered here where a sum has been solved more than one method.

(iii). Then the answer scripts of the said question papers were given to some expert examiners to examine. They also have suggested some alternative methods or techniques to solve some items.

(iv). The answer scripts have been re-written incorporating the views of the expert examiners.

(v). All the details of the solutions have been worked out (analysed in detail up to elementary level concepts) to find out all possible elementary concepts with their frequencies of occurrences which have been used in the solutions.

(vi). In this phase of detail-analysis, again experts' opinions were sought and their opinions were incorporated. Then final form of the solutions for each items have been prepared.

(vii). The elementary concepts which have been used in the solutions of each item have been identified and separated.

(viii). Now the frequency of elementary concept of the item is the total number of elementary concept used to solve the sum in a single method. In case where a particular item has been solved in more than one method, the number of elementary concepts used and their frequency have been determined by using the following criteria:

All the elementary concepts used in different methods have been selected and maximum frequency of each elementary concept within different methods has been taken as the frequency of that concept.

(ix). Then elementary concepts which are used in I.C.S.E. Examination (2005 & 2006) were counted.

(x). Both algebraic and arithmetical elementary concepts have been considered in some cases when the algebraic method has been used to solve the arithmetical problem.

For example, $3 + 2 = 5$

Algebraic elementary concept: addition of two positive integers.

Arithmetical elementary concept: horizontal addition of two one-digit numbers except zero where the sum is one-digit number.

(xi). Top forty four frequently used elementary concepts determined by their frequency of use of algebra of I.C.S.E. Examination (2005 & 2006) have been identified.

(xii). The rank orders of these elementary concepts according to their frequency of use have been determined.

(xiii). Identified the elementary concepts which were introduced or not in the prescribed text books of mathematics of N.C.E.R.T. from the top forty four frequently used elementary concepts.

5. Major Findings

Using the above method, top forty four elementary concepts according to its number of use in algebra of I.C.S.E. Examination (2005 & 2006) of C.I.S.C.E. have been identified and it has also been identified those concepts which were introduced or not in the prescribed text books of N.C.E.R.T. These concepts, their frequency of use, their rank orders and have been presented below in column 2, 3 and 4 of Table-1 respectively. For better understanding of these elementary concepts, Question (Q) is given in almost all concepts in column 2 of Table-1. Here, in column-5 of Table-1, the symbol '*' represent the concepts which had not been introduced in the prescribed text books of mathematics of N.C.E.R.T.

Table 1. A list of forty four elementary concepts of algebra according to frequency of use in algebra of I.C.S.E. Examination

1	2	3	4	5
Sl. No.	Name of the elementary concept	Frequency of use	Rank	Symbol
1.	Multiplication of monomials (when the monomials are two). Q. Multiply: i) 3 x m ii) $3a^2$ x 2a	45	1	
2.	Multiplication of positive integer by positive integer. Q. Multiply the first integer by the second. 8,12	36	2	
3.	Division of integer: if both the dividend and divisor are of positive sign, then the quotient is positive. Q. Find: $16 \div 2$	26	3	
4.	For all integers a and b, a + b = b + a. Q. Fill in the blanks. i) $3 + 7 = 7 + \dots$ ii) $x + y = \dots + x$	24	4	
5.	Addition of zero with any algebraic expression is equivalent to the same algebraic expression. Q. Add: 3a + 2b, 0	19	5	*
6.	Division of a monomial by a monomial (when exactly divisible).Q.Divide x by x.	18	6	
7.	Addition of two positive integers. Q. Add: +7, +4	16	7	
8.	Multiplication of binomial by monomial (horizontal multiplication). Q. Multiply: i) 2x(3y+2z) ii) $(3a^2$ - 2b)2a	15	8	
9.	If equal quantities are subtracted from equal quantities, the differences will also be equal.	15	9	
10.	If equal quantities are divided by equal quantities, the quotients will also be equal.	13	10	
11.	Addition of like monomials (when monomials are two).Q. Add: 2ab, -3ab	12	11.5	

1	2	3	4	5
Sl. No.	Name of the elementary concept	Frequency of use	Rank	Symbol
12.	Subtraction of algebraic expression: subtraction of two like monomials.Q. Subtract : m, 2m	12	11.5	
13.	Concept of cross multiplication.If a/b = c/d then ad = bc	10	14	
14.	Solving linear equation (in fractional form).Q. Solve $2x/5 = 3/5$	10	14	
15.	Integers as rational numbers.Q. Write the following integers as rational numbers with denominator 1.7, -11 [A : 7=7/1, -11= -11/1]	10	14	
16.	Factorization of binomial using the commutative law and distributive law of multiplication (when common factor is monomial positive).Q. Factorize: 8 + 4p	8	16	
17.	Finding a+(-b) or (-b) + a if $a = |-b|$ without number line.Q. Add: +3, - 3	7	18	
18.	Subtraction of two positive integers (when minuend > subtrahend) Q. Subtract : (+12)-(+7)	7	18	
19.	Subtraction of two positive integers (when minuend = subtrahend) Q. Subtract : (+17) - (+17)	7	18	$*$
20.	Subtraction of integer and zero.Q. Find: 0 - (+3)	6	21	
21.	Expression using addition: writing by using sign and symbols. Q. Write by using sign. Sum of p and q	6	21	
22.	Division of an algebraic expression by 1.Q. Divide: i) 2x + 3y by 1 ii) p by 1	6	21	$*$
23.	If a is a non-zero integer, then 0a=0 but a0 is not meaningful.Q. Find: 0(- 5) (A: 0)	5	24.5	
24.	Multiplying positive integer by negative integer or negative integer by positive integer. Q. Multiply the first integer by the second integer.i) 5, (-5) ii) (- 7), 3	5	24.5	
25.	For all integers a and b then a x b = b x a.	5	24.5	
26.	If equal quantities are added to equal quantities, the sums will also be equal.	5	24.5	
27.	Concept of a squared or a raised to the power 2 or a raised to the exponent 2:			
27.	finding the value (positive integral power of positive integer).Q. Find the value 30^2.	4	29	
28.	Concept of opposite numbers.Q. What is the opposite number +7? (A: -7)	4	29	$*$
29.	If x, m and n be any algebraic symbol representing number then x^m x $x^n = x^{m+n}$ Q. Multiply: p x p^2	4	29	$*$
30.	Concept of a squared or a raised to the power 2 or a raised to the exponent 2 (exponent of algebraic symbol representing number). Q. Write, using power notation.k x k (A : k^2)	4 / 4	29 / 29	
31.	Multiplication of two rational numbers.Q. Multiply : 2/7 by (-3/5)	4	29	
32.	Addition of integer and zero.Q. Add: +6, 0	3	38	
33.	Multiplying negative integer by negative integer.Q. Multiply first integer by second.(-3), (-7)	3	38	
34.	Expression using subtraction: writing by using sign and symbols. Q. Rahim is 20 years old. What was his age y year before?	3	38	
35.	Division of a monomial by a monomial (when not exactly divisible).Q. Divide: $3y^3$ by y^2 x.	3	38	$*$
36.	Division of a binomial by a binomial when exactly divisible (factors method). Q. Divide: a^2+ab by a+b.	3	38	$*$
37.	If P(x) is a polynomial of degree n>1 and a is any real number, then i) (x-a) is a factor of P(x) if P(a)=0 and ii) P(a)=0 if (x-a) is a factor of P(x).	3	38	
38.	Simple form of the algebraic expression (for middle term factorization) when co-efficient of the 1st term (includes the highest degree of relevant variable) is 1(one) and 3rd term (relevant variable free term) is integer (whole number).Q. Factorize: x ^{2}+4x+3	3	38	
39.	Rearrangement of term for factorization. Q. Rearrange the terms for factorization.ab+kc+ka+bc (A:ab+bc+ka+kc)	3	38	
40.	Factorization of binomial terms when common factor is monomial negative. Q. Factorize: -8+4x	3	38	$*$
41.	Factorization of binomial terms when common factor is binomial positive. Q. Factorize: 4(2+x)+x(2+x)	3	38	
42.	Formation of linear equation. Q. Form a linear equation.The sum of a number and seven is thirteen.	3	38	
43.	Ratio can be expressed as fraction.Q. Write down the following ratio as fraction.a:b	3	38	$*$
44.	The sum of two rational expressions is a rational expression.	3	38	

In the above Table-1, first ten elementary concepts and the elementary concepts of sl. no-16 out of forty four elementary concepts which have different frequency of use and rank orders. The elementary concept sl. nos. 11 & 12, each of their frequency is 12 and rank order is 11.5, elementary concept sl. nos. 13, 14 & 15, each of their frequency is 10 and rank order is 14, sl. nos. 17, 18 & 19, each of their frequency is 7 and rank order is 18, sl. nos. 20, 21 & 22, each of their frequency is

6 and rank order is 21, sl. nos. 23, 24, 25 & 26, each of their frequency is 5 and rank order is 24.5, sl. nos. 27, 28, 29, 30 & 31, each of their frequency is 4 and rank order is 29, sl. nos. from 32 to 44, each of their frequency is 3 and rank order is 38.

6. Conclusion

(i). This methodology helps to identify the elementary concepts of algebra and their rank orders which are used to solve the mathematical problems of different Board examinations.

(ii). According to rank orders, it may be said that there are some concepts which have equal importance.

(iii). Table-1 reveals the top forty four elementary concepts of algebra which have been identified according to frequency of use in two years mathematics question papers of I.C.S.E. Examination (2005 & 2006).

(iv). It is interesting that 9 elementary concepts (concept sl. nos. 5, 19, 22, 28, 29, 35, 36, 40, 43) out of 44 had been omitted in the prescribed textbooks of mathematics of N.C.E.R.T. So, it was a major gap. These should be considered in the prescribed text books.

(v). This study will help to identify the weakness of the learners after taking an investigation, those learners who are going to appear the ICSE Examination.

(vi). The teachers as well as learners will also be benefited in several ways like to diagnose the weakness of the learners, to find the difficult order of these concepts, to emphasize on the learning of these concepts at appropriate grade levels etc. after knowing these elementary concepts.

(vii). Learners should be properly acquainted to these elementary concepts at the appropriate level which will help to perform better at the 10th standard Board examination of C.I.S.C.E.

7. Further Study

(i). To identify the order of difficulty of the top forty four elementary concepts of algebra among the 10th standard learners.

(ii). To diagnose the weakness of the students in the top forty four elementary concepts of algebra.

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