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RESEARCH PAPER

Development and validation of Critical Thinking in Mathematics Test (CTMT) for 10th Grade Students

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ABSTRACT

Critical thinking is one of the most desirable qualities for educational and professional success in this age. Thinking critically is helpful for students to excel in learning and life. This study focuses on the development and validation of critical thinking in mathematics test (CTMT) for 10th grade students. The study includes seven steps ranging from development to validation phase (content selection, table of Specification, development of the Items, validity, pilot Testing, item Analysis and final instrument). There were 68 items initially made using inductive and deductive approaches which comprise face validity, content validity, construct validity and criterion validity as were confirmed by the experts', and statistical results of difficulty level of items and discrimination analysis. The reliability analysis also confirmed suitable consistency for the instrument. After going through the validity process, a total of 30 items remained as final items for this instrument. Full details of item analysis, reliability analysis and validation are discussed.

Introduction

For the development of intellectual and problem solving faced by students in their daily lives, critical thinking (C.T) skills are considered very important and also a part of life skills. In mathematics, Critical thinking skills are based on cognitive processes, which are used to solve different problems faced in daily life (Paul, 2007).

Critical thinking skills prepare students to learn about different sets and patterns of facts and figures and implementation of them to solve different problems in their routine lives. It motivates them to engage themselves in the world around themselves and to prepare others for thinking critically (Nelson, 2013).

Literature Review

Critical thinking skills are described the abilities of combining, mathematically reasoning, generalization, proving, rationalizing and evaluate systematically. An individual must have an attitude towards mathematics and intellectual constellation for the development and use of critical thinking in mathematics (Kereluik, 2013).

All over the world, mathematics is considered as fundamental and important subject for students to develop logical thinking and problem-solving skills. Mathematics education has a very vital role to educate students, how to think critically and solve the problems faced by them in their daily lives, acting as responsible and cooperative citizens in the society. Since last few decades, the objective of teaching mathematics is developing critical thinking and problem-solving skills among students (Kuntze et al., 2017).

According to the literature found related to the critical thinking in mathematics, it is a set of cognitive skills used to conclude logically and decision making in solving mathematical problems (Aizikovitsh-Udi & Cheng, 2015). It is also considered as an attitude to reflect regarding use and role of mathematics in different aspects of society i.e., social, political and cultural settings for the promotion of democracy in society. The first point described the significance of development of critical thinking among students to acquire different skills to solve problems and decision making in their daily lives. Whereas, second point highlights the importance of teaching of mathematics and development of critical thinking as reflection of analysis and evaluation of society. Furthermore, this described the importance of imparting critical thinking skills among students related to cognitive and social aspects of learning of mathematics as subject (Gutstein et al., 1997).

Material and Methods

Research Design

The main purpose of the study was to develop and validate critical thinking in mathematics test (CTMT) for 10th grade students. The study was developmental research. The study includes seven steps ranging from development to validation phase (content selection, table of Specification, development of the Items, validity, pilot testing, item Analysis and final instrument).

Results and Discussion

Development of Critical Thinking in Mathematics Test (CTMT)

The development and promotion in critical thinking is the foundation for academics. Bloom's Taxonomy used as base in teaching and learning for development of SLOs from curriculum. The taxonomy is very effective and mostly uses to assess different types of knowledge (factual, conceptual, procedural, and metacognitive) and development of higher-level cognitive skills (remembering, understanding, applying, analyzing, evaluating and creating). Bloom's Taxonomy is a perfect guide for an effective teacher (Heonga et al., 2012). Critical thinking of 10th grade students was tested through (MCQs). Final three levels of Blooms' Taxonomy (Analyzing, Evaluating and Creating) were taken as critical thinking.

Content for Critical Thinking in Mathematics Test (CTMT) in Mathematics

The content selected for the critical thinking MCQs test was a curriculum provided by Punjab Text Book Board (2006) Pakistan, titled as Text Book of Mathematics10th grade studied in all Punjab. This content is divided in 13 chapters, 50% of all syllabus (6 chapters) were selected. The content was consisted of 103 students learning outcomes having 34 SLOs related to upper three levels (analyzing, evaluating, and creating) of Bloom's taxonomy which were constructed by the help of (National Curriculum for Mathematics Grades IX – X, 2006)

Table of Specification for Critical Thinking in Mathematics Test (CTMT)

It is very difficult to decide how a researcher or teacher can measure critical thinking by a typical scoring scheme that supported by factual concepts. Scoring the level and quality of human thinking and reasoning is not a bed of roses. That's why researcher made MCQs test to Measure critical thinking. For the purpose teacher must use graded tests supported by a well-established scoring schemes or table of specification (Abdullaha & Osmanb, 2010).

Thus, the below-mentioned table of specification (TOS) was incorporated for the development of the test, namely Critical Thinking in Mathematics Test (CTMT).

Table 1
Table of Specification for Critical Thinking in Mathematics Test (CTMT)

Sr. No.	Chapter Name	Analyzing Questions	Evaluating Questions	Creating Questions	Total	%Weightage
1	Theory Of Quadratic Equation	0	02	02	04	6
2	Partial Fraction	08	0	0	8	12

3	Sets And Functions	06	20	08	34	50
4	Basic Statistics	06	08	08	22	32
	Total	20	30	18	68	100

Table 1 shows the table of Specification CTMT. Two MCQs were developed against each SLO. There were 34 SLOs related to the analyzing, evaluating and creating levels of cognitive domain. This test consisted the domains of analyzing (20) and evaluating (30) and domain of creating (18).

Development of the Items of Critical Thinking in Mathematics Test (CTMT)

Primarily, sixty-eight (68) items (two-tiered Multiple-Choice Questions) and the answer key were developed for the Critical Thinking in Mathematics Test (CTMT) by the penal discussion of 5 subject specialists of Mathematics at QAED Pasrur, District Sialkot and QAED Narowal. The items and the answer key of the preliminary draft were discussed with the experts for guidance, restructuring, and rectification. Expert opinion was got from the items' developers, items reviewers and experts of Punjab Examination Commission Lahore. All the experts provided their valuable opinion about the instruction, diagrams, construct, relevancy, appropriateness, and level of the stem's cognitive domain and the distractors, language clarity, meaningfulness of the items, and content coverage.

Validity of Critical Thinking in Mathematics Test (CTMT)

Without ensuring the validity, a test gain nothing. Face validity refers to the relevance, clarity, reasonableness, and unambiguousness of the items (Oluwatayo & Adebule, 2012). Content validity is essential in the achievement test. It refers to the extent to which a test measures a representative sample of the subject matter content. Principally, Construct Validity deals with the psychological meaningfulness of the test. Taherdoost (2016), cited that it discriminates one latent variable with other latent variables (i.e., how "a" discriminates with b, c, and d). Criterion-related validity is the extent to which the test performance is related to some other valued performance measure (Aulia et al., 2017). The overall validity of tests is improved if items of the test are appropriately analyzed (Odukoya et al., 2018). Educational researchers have already specified various components and measuring techniques to ensure validity.

Therefore, construct validity was ensured by item analysis, and criterion predictive validity was ensured by discriminant analysis. Similarly, validity, including content validity and face validity, was ensured by allocating appropriate weightage/percentage to SLOs and content. Similarly, it was ensured after seeking the valuable opinion of Subject Matter Experts (SMEs). They provide their opinions

on each item of the test in terms of "Essential", "Necessary," and "Un-necessary" item. Therefore, the Content Validity Ratio (CVR) and Content Validity Index (CVI) was calculated accordingly.

Hence, 54 items were retained, and fourteen (14) items were deleted. Similarly, Content Validity Index (CVI) value was computed to ensure the validity of the test. Its value remained 0.92, which was greater than 0.7, which is an acceptable value. This indicates that experts endorsed the validity, including content validity and face validity.

Pilot Testing of Critical Thinking in Mathematics Test (CTMT)

The Critical Thinking in Mathematics Test (CTMT) comprising fifty-four (54) items was pilot tested on 280, 10th grade students. Different quality statistics like the level of difficulty (p), Discriminating Power (D), and Test Item Reliability (Aulia et al., 2017) of the Critical Thinking in Mathematics Test (CTMT) were computed by using M.S. Excel, 2013.

Level of difficulty (p)

Aulia et al. (2017), have described five levels of item difficulty based on Prop Correct value, i.e., very difficult, difficult, average, easy, and very easy. The items having proportion correct value ranging from 0.000 to 0.099 are termed as very difficult. The items are called "difficult" with proportion correct value ranging from 0.100 – 0.299, "average" with proportion correct value ranging from 0.300 – 0.700, "easy" with proportion correct value ranging from 0.701 – 0.900, and "very easy" with proportion correct value ranging from 0.901 – 1.000.

Discriminating Power (D)

Discriminating power (D) differentiates between the high achievers (upper quartile students who answered correctly) and low achievers (lower quartile students who responded correctly) (Aulia et al., 2017). It was identified that Discriminating Index is the primary method to measure discriminating power (D). Whereas, Zaidi et al. (2018), pointed out that a point-biserial correlation (rpbis) is used to measure discriminating power (D). The value of point biserial indicates that the right persons are receiving the correct item. It further indicates the predictive power of the item. According to Aulia et al. (2017), Discriminating power of items on point Biserial value is indicated as; equal or below 0.199 (Very Low) needs to drop out or complete revision, 0.200-0.299 (Low) needs revision, 0.300-0.399 (Average) declared as good and values range equal or above 4.00 (High) is declared as very good.

Discrimination Index (DI)

The capability of an item to discriminate among high-performing and low-performing students is called a Discrimination Index (Aulia et al., 2017). Its value ranges from -1 to +1. Kolte (2015), suggested the comprehensive criteria for Discrimination Index (DI) as; Range value of discrimination index below zero (Very poor) must be dropped, range value equal to zero (Poor) must be dropped, 0.00-0.19 (Acceptable) may be retained, 0.20-0.34 (Good) must be retained and range value equal or above 0.35 (Excellent) must be retained.

Reliability (α)

The alpha value indicates the test reliability in terms of low, average, and high reliable tests. A test with high reliability is one that reproduces the same relative importance of test scores for a group of students under different conditions or situations (Aulia et al., 2017).

The test is low/not sufficient reliable if the alpha value ranges from 0.000 to 0.400. Similarly, it is average/sufficient reliable if the alpha value ranges from 0.401 to 0.700. However, the test is good/high reliable if the alpha value ranges from 0.701 to 1.000.

Item Analysis of Critical Thinking in Mathematics Test (CTMT)

Different values like Point Biserial, Discriminating Index and difficulty level were computed by using M.S Excel 2013 software.

Table 2
Item wise statistics of Critical Thinking in Mathematics Test (CTMT)

Item No.	Level of difficulty (p)	Point Biser	Disc. Index	Status of Items			Remarks
				Based on Prop. Correct	Based on Point Biser	Based on Disc. Index	
1	0.70	0.4	0.19	Average	High	Acceptable	Retained
2	0.90	0.1	0.00	Very Easy	Very Low	Poor	Rejected
3	0.26	0.0	-0.01	Difficult	Very Low	Poor	Rejected
4	0.70	0.4	0.21	Average	High	Good	Retained
5	0.23	0.28	-0.08	Difficult	Low	Poor	Rejected
6	0.56	0.4	0.24	Average	High	Good	Retained
7	0.70	0.4	0.21	Average	High	Good	Retained
8	0.20	0.28	-0.07	Difficult	Low	Poor	Rejected
9	0.90	0.10	-0.09	Easy	Very Low	Poor	Rejected
10	0.50	0.5	0.25	Average	High	Good	Retained
11	0.86	0.18	-0.11	Easy	Very Low	Poor	Rejected
12	0.13	0.19	-0.11	Difficult	Very Low	Poor	Rejected
13	0.93	0.0	0.00	Very Easy	Very Low	Poor	Rejected

14	0.70	0.5	0.21	Average	High	Good	Retained
15	0.91	0.27	-0.06	Very Easy	Low	Poor	Rejected
16	0.56	0.32	0.24	Average	Average	Good	Retained
17	0.92	0.1	-0.09	Very Easy	Very Low	Poor	Rejected
18	0.63	0.5	0.23	Average	High	Good	Retained
19	0.83	0.3	-0.13	Easy	Average	Poor	Rejected
20	0.53	0.41	0.36	Average	High	Excellent	Retained
21	0.86	0.24	-0.11	Easy	Low	Poor	Rejected
22	0.60	0.33	0.24	Average	Average	Good	Retained
23	0.46	0.21	0.24	Average	Low	Good	Retained
24	0.80	0.1	-0.16	Easy	Very Low	Poor	Rejected
25	0.23	0.2	-0.17	Difficult	Low	Poor	Rejected
26	0.70	0.5	0.19	Average	High	Acceptable	Retained
27	0.63	0.35	0.23	Average	Average	Good	Retained
28	0.53	0.40	0.24	Average	High	Good	Retained
29	0.53	0.43	0.24	Average	High	Good	Retained
30	0.90	0.0	0.00	Easy	Very Low	Poor	Rejected
31	0.60	0.36	0.24	Average	Average	Good	Retained
32	0.66	0.4	0.35	Average	High	Excellent	Retained
33	0.46	0.4	0.24	Average	High	Good	Retained
34	0.43	0.5	0.24	Average	High	Good	Retained
35	0.53	0.41	0.24	Average	High	Good	Retained
36	0.86	0.0	-0.11	Easy	Very Low	Poor	Rejected
37	0.93	0.27	-0.06	Very Easy	Low	Poor	Rejected
38	0.46	0.30	0.24	Average	Average	Good	Retained
39	0.43	0.30	0.19	Average	Average	Acceptable	Retained
40	0.70	0.43	0.19	Average	High	Acceptable	Retained
41	0.53	0.6	0.24	Average	High	Good	Retained
42	0.80	0.2	-0.16	Easy	Low	Poor	Rejected
43	0.66	0.44	0.22	Average	High	Good	Retained
44	0.70	0.51	0.21	Average	High	Good	Retained
45	0.80	0.0	-0.16	Easy	Very Low	Poor	Rejected
46	0.40	0.5	0.24	Average	High	Good	Retained
47	0.90	0.0	-0.28	Easy	Very Low	Poor	Rejected
48	0.66	0.5	0.22	Average	High	Good	Retained
49	0.60	0.37	0.24	Average	Average	Good	Retained
50	0.20	0.23	-0.16	Difficult	Low	Poor	Rejected
51	0.80	0.0	-0.16	Easy	Very Low	Poor	Rejected
52	0.60	0.5	0.24	Average	High	Good	Retained
53	0.90	0.0	-0.28	Easy	Very Low	Poor	Rejected
54	0.46	0.17	0.00	Average	Very Low	Poor	Rejected

Table-2 represents the item-wise statistics of the Critical Thinking in Mathematics Test (CTMT). Descriptive statistics results of the test provide necessary information regarding the pilot testing. Twenty-four (24) items of the Critical Thinking in Mathematics Test (CTMT) remained below the acceptable value of quality items.

Final Critical Thinking in Mathematics Test (CTMT)

By adopting the above-cited, evidence-based review of test items, poor-performing items were dropped out from the test. Only thirty (30) Multiple Choice Questions (MCQs) remained fit to retain after item analysis. After removing the weak items, the reliability (Cronbach's alpha value) of the CTMT on valid items was 0.826, which is higher than 0.7. Thus, Critical Thinking in Mathematics Test (CTMT) was highly reliable. Test Statistics of the final Test (CTMT) in the below-mentioned table indicates item-wise test statistics consisting of thirty (30) Multiple Choice Questions (MCQs).

Table 3
Item wise statistics of Final Critical Thinking in Mathematics Test (CTMT)

Item No.	Level of difficulty (p)	Point Biser	Disc. Index	Status of Items			Remarks
				Based on Prop. Correct	Based on Point Biser	Based on Disc. Index	
1	0.70	0.4	0.19	Average	High	Acceptable	Retained
2	0.70	0.4	0.21	Average	High	Good	Retained
3	0.56	0.4	0.24	Average	High	Good	Retained
4	0.70	0.4	0.21	Average	High	Good	Retained
5	0.50	0.5	0.25	Average	High	Good	Retained
6	0.70	0.5	0.21	Average	High	Good	Retained
7	0.56	0.32	0.24	Average	Average	Good	Retained
8	0.63	0.5	0.23	Average	High	Good	Retained
9	0.53	0.41	0.36	Average	High	Excellent	Retained
10	0.60	0.33	0.24	Average	Average	Good	Retained
11	0.46	0.21	0.24	Average	Low	Good	Retained
12	0.70	0.5	0.19	Average	High	Acceptable	Retained
13	0.63	0.35	0.23	Average	Average	Good	Retained
14	0.53	0.40	0.24	Average	High	Good	Retained
15	0.53	0.43	0.24	Average	High	Good	Retained
16	0.60	0.36	0.24	Average	Average	Good	Retained
17	0.66	0.4	0.35	Average	High	Excellent	Retained
18	0.46	0.4	0.24	Average	High	Good	Retained
19	0.43	0.5	0.24	Average	High	Good	Retained
20	0.53	0.41	0.24	Average	High	Good	Retained
21	0.46	0.30	0.24	Average	Average	Good	Retained
22	0.43	0.30	0.19	Average	Average	Acceptable	Retained
23	0.70	0.43	0.19	Average	High	Acceptable	Retained
24	0.53	0.6	0.24	Average	High	Good	Retained
25	0.66	0.44	0.22	Average	High	Good	Retained
26	0.70	0.51	0.21	Average	High	Good	Retained
27	0.40	0.5	0.24	Average	High	Good	Retained
28	0.66	0.5	0.22	Average	High	Good	Retained
29	0.60	0.37	0.24	Average	Average	Good	Retained
30	0.60	0.5	0.24	Average	High	Good	Retained

Table-3 represents the retained items (thirty (30) Multiple Choice Questions). items No. 1, 4, 6, 7, 10, 14, 16, 18, 20, 22, 23, 26, 27, 28, 29, 32, 33, 34, 35, 39, 41, 43, 44, 46, 48, 49, 51, 52, 54 and 56 were retained in the critical thinking in mathematics test (CTMT).

Table 4
Final Critical Thinking in Mathematics Test (CTMT)

1	**If $7x^2+8x+1=0$ Then the roots will be**			
	a) Rational and unequal	b) Imaginary and unequal	c)Rational and unequal	d) Imaginary and unequal
2	If α, β are the roots of $x^2-x-1=0$ then the product of the roots 2α and 2β is			
	a)-2	b)2	c)4	d)-4
3	Partial fraction of $\frac{7x+25}{(x+3)(x+4)}$ are the form.			
	$a)\frac{3}{x}+\frac{5}{x+4}$	b) $\frac{4}{x+4}+\frac{5}{(x+4)^2}$	$c)\frac{4}{x+3}+\frac{3}{x+4}$	d) $\frac{2}{x}+\frac{5}{x+4}$
4	Partial fraction of $\frac{9}{(xz-1)(x+2)^2}$ are of the form.			
	a) $\frac{A}{x-1}+\frac{B}{x+2}+\frac{C}{(x+2)^2}$	b) $\frac{A}{x-1}+\frac{B}{x+2}+\frac{Cx}{(x+2)^2}$	c) $\frac{A}{x-1}+\frac{Bx}{x+2}+\frac{C}{(x+2)^2}$	d) $\frac{A}{x+1}+\frac{B}{x-2}+\frac{Cx}{(x-2)^2}$
5	Partial fraction of $\frac{x^2+1}{(x+)(x-1)}$ are of the form.			
	a) $\frac{A}{x+1}+\frac{B}{x-1}$	b) $1+\frac{A}{x+1}+\frac{Bx+c}{x-1}$	c) $1+\frac{A}{x+1}+\frac{B}{x-1}$	d) $\frac{Ax+B}{x+1}+\frac{C}{x-1}$
6	The set A and B have 5 and 9 elements respectively such that A is proper subset of B, then the total number of elements in AUB are			
	a)5	b)9	c)14	d)4
7	If A and B are two sets, such that n(A)=15 and n(B)= 21 and n(AUB)= 36 then n(A ∩ B) is equal to			
	a)2	b)0	c)4	d)15
8	The set A and B have 6 and 9 elements respectively such that A and B are disjoint sets, then the total number of elements in A-B will be			
	a)3	b)6	c)9	d)15
9	If A ∩ B'=∅ then			
	a) A=B	b) B≠A	c)A is proper subset of B	d) A is subset of B
10	Let A=N, B=W then proving the commutative property of union of set. The correct answer is.			
	a) N	b) W	c) ∅	d)E
11	Let A = W, B = N Than proving the commutative property of intersection of sets. The sets will be.			
	a) A∩B = N, B∩A = W	b) A∩B = N, B∩A = N	c) A∩B = W, B∩A = W	d) A∩B =∅, B∩A = ∅
12	Let A = {0,1,2,3} B = {1,2,3} C = {1,3} Then prove the associative property of union of set, the element of required set are:			
	a) {0,1,2,3}	b) {1,2,3}	c) {1,3}	d) ∅

13	If A = W, B = N and C = 0 Then to prove the association property of intersection of sets, the correct option will be:			
	a) A∩(B∩C) = O, (A∩B)∩C = O	b) A∩(B∩C) = W, (A∩B)∩C = N	c) A∩C = O, A∩B = N	d) A∩B = N, B∩A= N
14	Let A=R, B=∅ and C=E then prove distributive property of union over intersection, find the correct option:			
	a) AU(B∩C) = R, (AUB) ∩ (AUC) = R	b) A∩(BUC) = ∅, (A∩B) U (A∩C) = ∅	c) (AUB)UC = R, (A∩B) ∩C = E	d) (AUB)UC = R, (AUB)U(A UC) = R
15	Let A=R, B=∅ and C=E Then prove distributive property of intersection over union, the correct answer will be:			
	a) A∩(BUC) = ∅, (A∩B)U(A∩C) = ∅	b) AU(B∩C) = R, (AUB)∩(AUC) = ∅	c) A∩(BUC) = ∅, (AUB)∩(AUC) = ∅	d) (AUB)UC = R, (A∩B) ∩C = E
16	Analyze whether the given relation is a function R= {(1,2),(2,3),(3,3),(3,4)}			
	a) Onto function	b) Into function	c) Not a function	d) One-one function
17	If A= {0,1,2,3}, B= {1,2,3,4,5} then the given function f : A→ B f = {(x,y)/ y = x+1, ∀ X∈A, y∈B} will be:			
	a) Into function	b) One-one function	c)Onto function	d)Bijective function
18	If A= {1,2,3,4}, B= {2,3,4,5} then given function f: A → B such that f = {(x,y)/ y= x+1, x∈A, y∈B} will be:			
	a) Into function	b) onto function	c)one-one function	d)Bijective function
19	During construction of frequency distribution, the class width is 4 and the lower limits of first class is 10. If there are 6 classes, then upper limit of last class is:			
	a)22	b)26	c)30	d)34
20	For the following data of frequency of polygraph which will be the mid-point of class III **Class limit** 10 – 19, 20 – 29, 30 – 39 **Frequency** 10, 5, 9 **Mid-point** 14.5, 24.5, ?			
	a)34.5	b)30.5	c)44.5	d)9
21	In the construction of cumulative frequency polygon, the cumulative frequency of the last class for given data will be: Class limits 4-6, 7-9, 10-12, 13-15 Frequency 2, 4, 8, 3			
	a)2	b)8	c)17	d)11
22	The arithmetic Mean of 12 observations is 7.5. If the arithmetic means of 7 these observations is 6.5, then the Mean of remaining observations is:			
	a)5.5	b)8.5	c)8.9	d)9.2
23	If the Median of given data 12,13,16, x+2, x+4,28,30,32 is 23, when x+2, x+4 lies between 16 and 30, then the value of x is:			
	a)18	b)19	c)20	d)22
24	If the mode of given data; 12,16,9,16,x,12,16,19,12 is 16, then value of x is:			
	a)12	b)16	c)19	d)18
25	If $\frac{a^{n+2}+b^{n+2}}{a^{n+1}+b^{n+1}}$ is the Geometric means between a and b, then the value of n is:			
	a)-1	b)1	c)-2	d)-0.5
26	If arithmetic Mean is 20 and geometric Mean is 24.94, then the harmonic mean is:			

	a)20	b)25	c)30	d)35
27	If the beginning work in process equivalent units are 2500 units, work done in current period equivalent units are 3800 units, and ending work in process equivalent units are 5000 units, then complete equivalent units in current period are:			
	a)1800	b)1500	c)1300	d)1200
28	The highest marks of the students of class 10th in Mathematics are 74 and the lowest obtained marks by students are 13, what will be the range value of the marks in Mathematics?			
	a)60	b)61	c)87	d)37
29	If the total sum of squares is 20 and sample variance is 5, then total number of observations are:			
	a)15	b)25	c)4	d)35
30	The total revenue (in Crore) of five companies are as; two companies have revenue between 10-20, and one company has revenue between 20-30, and one company has revenue between 30-40, then what will be the standard Deviation?			
	a)7.9	b)4.9	c)5.9	d)6.9

Conclusions

1. Critical Thinking in Mathematics Test (CTMT) can actually measure critical thinking in mathematics of 10 grade students.
2. Content Validity Index (CVI) value remained 0.92, which was greater than 0.7, which is an acceptable value. Each item was found statistically significant.
3. The estimated difficulty level of items ranges from 0.300 – 0.700 which means there were no item that was too difficult or too easy.
4. Discrimination Index (DI) of items ranged from 0.20-0.34 (Good) and equal or above 0.35 (Excellent), which means all retained items were good and excellent.
5. The reliability (Cronbach's alpha value) of valid items was 0.826, which was higher than 0.7. Thus, Critical Thinking in Mathematics Test (CTMT) was highly reliable.
6. Final Critical Thinking in Mathematics Test (CTMT) consisted of 30 MCQs items (12 Analyzing MCQs, 10 Evaluating MCQs and 08 Creating MCQs).

Recommendations

1. On the basis of conclusions, it is recommended that Critical Thinking in Mathematics Test (CTMT) is valid and reliable. So, it may be used for formative and summative assessment.
2. Further tests to assess critical thinking of students in other science subjects may be developed.
3. Teachers may be trained to develop different tests to assess critical thinking of students for better learning.

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