Chapter-5
Tool Construction

5.1.0 Introduction
5.2.0 Selection of Content
5.3.0 Item Construction
  5.3.1 Some considerations for Action-oriented Competency based item writing
5.4.0 Logical Review of the Items
  5.4.1 Experts assessment
  5.4.2 Computation of IOCI (Item Objective Congruence Index)
    5.4.2.1 IOCI for Grade V
    5.4.2.2 IOCI for Grade VI
    5.4.2.3 IOCI for Grade VII
5.5.0 Try-outs
  5.5.1 Pre-pilot study
  5.5.2 Pilot Study
  5.5.3 Final Run
5.6.0 Process of Test Administration
  5.6.1 Format of the tests
  5.6.2 Tool Kit
  5.6.3 Length of the tests
  5.6.4 Time Duration
  5.6.5 Response sheet
  5.6.6 Scoring key
5.7.0 Conclusion
Chapter-5
Tool Construction

5.1.0 Introduction

The first main objective of the present study was to construct a reliable and valid test for each grade. It was a challenging task. A valid and reliable tool is very necessary to collect the data for any research work. So the selection of the tool should be done after a detailed study of the content and the subjects on which it is based.

According to Sukhia and Mehrotra (1966):

“The selection of suitable instrument or tool is of vital importance for successful research.”

According to Cronbach (1966):

“First, he must decide what he intends to measure. Second, he must invents or select items which serve that purpose. Third, he must find a measuring unit in which to express results. Fourth, he must show the validity of the test.”

The test was prepared for following purposes-

1. To examine the achievement level of the students on different competencies.
2. To know the effect of Gender on the achievement.
3. To know the effect of Area on the achievement

5.2.0 Selection of Content

Activity-oriented, Joyful learning and Competency based curriculum in the form of “statements” emphasizes the Competencies instead of the content. It rightly makes teacher

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aware that his success will be judged by the extent to which the competencies are acquired by most of the students of the sample. The competencies specified in the statement are the minimum or the most essential ones and are arranged in a hierarchial order. The state authorities with a State Resource Group (SRG) of Gujarat Council of Educational Research and Training (GCERT) have divided all the competencies into three parts. (1) Oral competencies (2) Action-oriented competencies and (3) Written competencies. Here the present study is only for Action-oriented Competencies for Mathematics of Grade Five, Six and Seven. (Excluding Oral and Written competencies). So the investigator has decided to constructed items in the light of these competencies. Steps for preparing the initial form of **Action-oriented** and Competency-based test in Mathematics for Grade V, VI and VII were as follows.

The investigator identified Action oriented competencies grade wise from the present syllabus. All these Action oriented competencies were further clubbed in fields. The present syllabus of grade V, VI and VII, it is not true that all the fields were incorporated in each Grade. Table: 5.2.1 shows fields and the presence of Action-oriented competencies.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Grade V</th>
<th>Grade VI</th>
<th>Grade VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field : 1</td>
<td>Number Knowledge</td>
<td>√</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Field : 3</td>
<td>Number System</td>
<td>-</td>
<td>√</td>
<td>-</td>
</tr>
<tr>
<td>Field : 4</td>
<td>Mathematics in daily life</td>
<td>-</td>
<td>-</td>
<td>√</td>
</tr>
<tr>
<td>Field : 6</td>
<td>Geometry</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Field : 8</td>
<td>Statistics</td>
<td>-</td>
<td>√</td>
<td>-</td>
</tr>
</tbody>
</table>

Here the fields appeared in grade were treated as domains. One can say that only field: 6 Geometry is present in all the three grades. While remaining fields are not common to all the grades.

As per present syllabus of Mathematics, each competency is shown in three digits. The first digit indicates grade, Second digit indicates field and third one indicates number of competency. If the competency is 6.5.2 means that it belongs to the field number six of grade five and its serial number in that grade is second one.

The content related to each competency were treated as a core content and it was used to construct items. The grade wise, field wise content is presented as follow:
List of Action-oriented Competencies in Mathematics for Grade V, VI and Grade VII

Grade V

Field - 1. Number knowledge
  • 1.5.1 The Pupil Identifies numbers from ten thousands to one crore and writes in figures.

Field - 6. Geometry
  • 6.5.2 The Pupil Draws angles of different measures using protractor and measures them.
  • 6.5.6 The Pupil Draws the center, radius, diameter and chord of a circle.
  • 6.5.10 The Pupil Draws circle with given radius.

Grade VI

Field - 3. Number System
  • 3.6.3 The Pupil Represents integers on the number line.
  • 3.6.6 The Pupil Arranges given integers between (-20) to 20 in ascending or descending order with the help of number line.

Field - 6. Geometry
  • 6.6.1 (A) The Pupil Gets idea about complementary angles and draws it.
  • 6.6.1 (B) The Pupil Gets idea about supplementary angles and draw it.
  • 6.6.4 (A) The Pupil Constructs a line perpendicular to a given line at a point given on it with the help of set-square.
  • 6.6.4 (B) The Pupil Constructs a line perpendicular to a given line through a point given outside the line with the help of set-square.
  • 6.6.5 The Pupil Constructs a triangle when the length of all the three sides are given.
  • 6.6.6 The Pupil Constructs a right angled triangle when the length of its hypotenuse and other sides are given.

Field - 8. Statistics
  • 8.6.4 The Pupil Draws the Conical graph on the basis of the data.

Grade VII

Field - 4. Mathematics in daily life
  • 4.7.11 The Pupil Knows about cheque and different types of cheques.

Field - 6. Geometry
  • 6.7.5 Draws a line parallel to a given line through a point outside it by using set square.
6.7.10 The Pupil Measures the angles of a quadrilateral and vertices that the sum of their measures is $360^\circ$

Thus, 16 competencies of Grade V, VI and VII which were included in the construction of present test.

5.3.0 Item Construction

Action oriented competency can be measure by using some mathematical instrument. In such situation, its item must be performance based. In competency based performance test item decides the performance of testee step-by-step. In such situation, it was a difficult task for the researcher. In any test construction, one has to have more test items to evaluate the performance of the testee.

All the identified action oriented competencies belongs to one or another field. As per Criterion Referenced Test (CRT), one has to decide “well defined behavioral domains”. Here, domains were fixed in the light of competency. In such situation, test items should be constructed in the light of CRT.

As per CRT, one has to construct at least ten items for each behavioral domain. The constructed items should be logically reviewed.

The item writing and item writing in CRT has its own problem and its own science. Looking to the science of item writing, one has to make some considerations. These considerations were as follows.

5.3.1 Some considerations for Action-oriented Competency based item writing:

1. The item should be such as would collect evidence on the mastery of the pupil of the Action-oriented competency which is being tested.
2. The item should aim at testing one competency at a time. If more competencies are included in an item, there is a possibility of some of ignorance and so getting exact feedback on those competencies would be difficult.
3. The item should be worded in such a way that the weak aspects of an acquired competency are revealed. Exact knowledge of weak spots enables the investigator to provide proper feedback to the pupil and to plan required remedial strategy for him.
4. The item should be framed according to the vocabulary of the pupil. Difficulty felt by the pupil in comprehending the words may result in wrong response.

5. The item should be of adequate length. The students get lost if the item is too lengthy and are confused if the item is short and vague.

6. Clear cut but short instructions should precede item writing.

7. An item should be challenging enough. The correct response to challenging task gives a respondent feeling of satisfaction and motivates him to prepare for further challenges.

8. An item should create interest among children taking the test.

   Familiar content, as well as that which takes the child to a new imaginary world creates interest in the child’s mind.

The selection of the material for item writing consideration listed above makes it clear to the investigator that developing Action-oriented and Competency based item was not an easy task. The investigator was herself closely connected with the process of the new Activity based, Joyful learning and Competency based textbooks of Mathematics for Grades V, VI and VII, as a member of State Resource Group in the State. Hence with the joining of hands of the other group persons, the work became easier as well as reliable.

The investigator tried to make her needs known to her friends, who were interested in primary level mathematics. They also compiled the material from Grade V, VI and VII and passed on for selection, adoption or modification.

At least seven or more possible items were prepared for each Action-oriented Competency from Grade V, VI and VII Mathematics. For each item the specific Action-oriented Competencies have already been mentioned and the items have been arranged in test form with particular competency number.

Having thorough experience of developing new textbook and common understanding of an Action-oriented- Competency based evaluation, the investigator prepared 7-10 items for each Action-oriented Competency. Details of the number of item for each Action-oriented Competency from grade V, VI and VII Mathematics are presented in the Table 5.3.1 that follows.
Table 5.3.1
Number of items for each Action-oriented Competency of Grade V, VI and VII Mathematics.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Competencies</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>04</td>
<td>31</td>
</tr>
<tr>
<td>VI</td>
<td>09</td>
<td>63</td>
</tr>
<tr>
<td>VII</td>
<td>03</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>115</strong></td>
</tr>
</tbody>
</table>

Thus total 115 items were prepared in all, for 16 competencies, which were selected for the tests. The aim behind preparing 7 items for each Action-oriented competency was to get the best item for testing the particular Action-oriented Competency. These all items are appended as Appendix-I.

5.4.0 Logical Review of the Items

After generating and its editing the items, a logical review was essential. The process of logical review of items was carried out by subject and research experts.

The logical review of items one has to compute Item Objective Congruence Index (IOCI). A final team of five subject experts ruled the match between item and competency of all the three tests from Grade V, VI, VII were calculated after the statistical analysis of ratings obtained from the experts.

5.4.1 Experts assessment

Following instructions in terms of request were handed over to experts along with statement of competencies with number and list of items constructed grade wise.

- Read the competency.
- Evaluate the item in the context of competency.
  - If the item have capability to measure the said competency concerned perfectly, than assign +1.
  - If the item have not capability to measure the said competency concerned perfectly, than assign -1.
- If you cannot decide it, than assign 0.

The experts were given the list of items in test format for Grade V, VI, VII and also a copy of the lists of competencies for Grades V, VI, VII. These are listed in Appendix.I. The letter containing request for help is also presented in Appendix-I.
They were also given copies of review sheets for Grades V, VI, VII. In this way the sheets of analysis of ratings were prepared after obtaining the ratings of items from all the experts for each item for Grade V, VI, VII.

5.4.2 Computation of IOCI (Item Objective Congruence Index)

In CRT, selection of item, is done on the basis of Item Objective Congruence Index (IOCI). Here the researcher decided to find out IOCI for each item as a first screening in item selection for the test to be constructed. The calculation of IOCI is done by using formula shown below.

\[
IOCI = \frac{(N-1)S_1-S_2+S_1}{2(N-2)n}
\]

Where

- \( N \) = Number of competencies in the said field
- \( n \) = number of subject matter experts (Reviewers)
- \( S_1 \) = Sum across all experts rating for one competency for one item
- \( S_2 \) = Sum of ratings across all experts for all competencies for one item

According to CRT, if the value of IOCI of any item is more than 0.9, than the item is considered as a very good item, It means that the item is efficient to measure the said well defined behavioral domain-Competency.

5.4.2.1 IOCI for Grade V

The ratings of all the five experts were tabulated as shown in Table 5.4.2.1. The illustrative calculation of item number 1 is shown below.

<table>
<thead>
<tr>
<th>Action-oriented Competency number</th>
<th>Subject Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>1.5.1</td>
<td>+1</td>
</tr>
<tr>
<td>6.5.2</td>
<td>-1</td>
</tr>
<tr>
<td>6.5.6</td>
<td>-1</td>
</tr>
<tr>
<td>6.5.10</td>
<td>-1</td>
</tr>
</tbody>
</table>

From the illustrative table 5.4.2.1, values of \( N, n, S_1 \) and \( S_2 \) were worked out from the said table. They were as under.
N = Number of competencies in the said field = 4
n = number of subject matter experts (Reviewers) = 5
S₁ = Sum across all experts rating for one competency for one item = 5
S₂ = Sum of ratings across all experts for all competencies for one item = (-7)

These values were put in the formula suggested in para 4.5.2.0 and IOCI was computed. The step-wise computation is presented as follow:

\[
\text{IOCI} = \frac{(N-1)S₁ - S₂ + S₁}{2(N-2)n}
\]

\[
= \frac{(4-1)\times 5 - (-7) + 5}{2(4-1)\times 5}
\]

\[
= \frac{15 + 7 + 5}{30}
\]

\[
= \frac{27}{30}
\]

\[
\text{IOCI} = 0.9
\]

The IOCI value of said item number one is 0.9. As per rules for IOCI, this item is able to measure the competency number 1.5.1 perfectly. This way IOCI for all the items selected for grade V were computed and are presented as Appendix II. It is observed from the said Appendix that all the of 31 items, were reached the said criteria. So that they were used for Pre-pilot study.

5.4.2.2 IOCI for Grade VI

The ratings of all the five experts were tabulated as shown in Table 5.4.2.2. The illustrative calculation of item number 1 is shown below.

<table>
<thead>
<tr>
<th>Action-oriented Competency number</th>
<th>Subject Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>3.6.3</td>
<td>-1</td>
</tr>
<tr>
<td>3.6.6</td>
<td>+1</td>
</tr>
<tr>
<td>6.6.1 A</td>
<td>-1</td>
</tr>
<tr>
<td>6.6.1 B</td>
<td>-1</td>
</tr>
<tr>
<td>6.6.4 A</td>
<td>-1</td>
</tr>
<tr>
<td>6.6.4 B</td>
<td>-1</td>
</tr>
<tr>
<td>6.6.5</td>
<td>-1</td>
</tr>
<tr>
<td>6.6.6</td>
<td>-1</td>
</tr>
<tr>
<td>8.6.4</td>
<td>-1</td>
</tr>
</tbody>
</table>
From the illustrative table 5.4.2.1, values of N, n, S1 and S2 were worked out from the said table. They were as under.

Where

\[ N = \text{Number of competencies in the said field} = 9 \]
\[ n = \text{number of subject matter experts (Reviewers)} = 5 \]
\[ S_1 = \text{Sum across all experts rating for one competency for one item} = 5 \]
\[ S_2 = \text{Sum of ratings across all experts for all competencies for one item} = (-33) \]

\[
\text{IOCI} = \frac{(N-1)S_1 - S_2 + S_1}{2(N-2)n}
\]
\[
= \frac{(9-1) \times 5 - (-33) + 5}{2(9-1) \times 5}
\]
\[
= \frac{40 + 33 + 5}{80}
\]
\[
= \frac{78}{80}
\]
\[
\text{IOCI} = 0.98
\]

The IOCI value of said item number one is 0.98. As per rules for IOCI, this item is able to measure the competency number 3.6.3 perfectly. This way IOCI for all the items selected for grade VI were computed and are presented as Appendix II. It is observed from the said Appendix that all the 63 items, were reached the said criteria. So that they were used for Pre-pilot study.

5.4.2.3 IOCI for Grade VII

The ratings of all the five experts were tabulated as shown in Table 5.4.2.3. The illustrative calculation of item number 1 is shown below.

<table>
<thead>
<tr>
<th>Action-oriented Competency number</th>
<th>Subject Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>4.7.11</td>
<td>+1</td>
</tr>
<tr>
<td>6.7.5</td>
<td>-1</td>
</tr>
<tr>
<td>6.7.10</td>
<td>-1</td>
</tr>
</tbody>
</table>

From the illustrative table 5.4.2.3, values of N, n, S1 and S2 were worked out from the said table. They were as under.
Where

\[ N = \text{Number of competencies in the said field} = 3 \]
\[ n = \text{number of subject matter experts (Reviewers)} = 5 \]
\[ S_1 = \text{Sum across all experts rating for one competency for one item} = 5 \]
\[ S_2 = \text{Sum of ratings across all experts for all competencies for one item} = (-5) \]

\[
IOCI = \frac{(N-1)S_1-S_2+S_1}{2(N-2)n}
\]

\[
= \frac{(3-1)x5-(-5)+5}{2(3-1)x5}
\]

\[
= \frac{10+5+5}{20}
\]

\[
= \frac{20}{20}
\]

\[ IOCI = 1 \]

The IOCI value of said item number one is 1.0 As per rules for IOCI, this item is able to measure the competency number 4.7.11 perfectly. This way IOCI for all the items selected for grade VII were computed and are presented as Appendix II. It is observed from the said Appendix that all 21 items reached the said criteria. So that they were used for Pre-pilot study.

After logical review of all the items, it was found that almost all the items constructed by the investigator were appropriate.

After carefully screening items constructed and revised by the investigator were selected for preparing sub-tests. i.e. test for grade V, VI and VII. These all items along with their IOCI presented in appendix II. A fresh sub-test for grade V, VI and VII was prepared for try-outs.

5.5.0 Try-outs

The investigator carefully studied the objectives of the study and conducted various try-outs of the tests.

1. The equivalence of the items in the various from of the test.
2. The difficulty value of each test items.
3. The discriminative index of each test items
4. The adequacy of the direction, the time limit and the test format.
5. Standardization of the test.
5.5.1 Pre-pilot study

The investigator carefully studied the objectives of pre-pilot of the test. They were as follows:

1. To find out the range of the applicability.
2. To standardize the instruction to be given for the whole test and also for each individual subtests.
3. To fix the time limit for each test.

Keeping these objectives in his mind, the investigator administered the Gujarati form of the test with response space on the sample stated in Table 4.5.1 in para 4.5.1. The investigator selected students by purposive sampling technique.

To measure the time taken by the respondents, the investigator has noticed three different time taken by Low Achiever, Medium Achiever and High Achiever. The time taken by the students for the tests were noted by the researcher. From that noting, average time for each sub-test i.e. grade wise was worked out and it was found 45 minutes.

Therefore it was decided required time for completing of test will be 45 minutes for all the three Grades. It was read from the first try-out (Pre-pilot) of the test that it has

1. Provided an experience for administrating the test.
2. Lead the investigator to make some correction in instruction to be given to the taste during the administration of the test.

Thus, the test was ready for pilot study and they are presented in Appendix-III.

5.5.2 Pilot Study

The objective of the Pilot Study were

1. To find out the Difficulty Value and Discrimination Index through the Item analysis and fix the time limit taken by the student averagely.
2. To modify instruction if needed.

The tests prepare for pilot study was administer to the sample stated in chapter-4, para 4.5.2 as per instructions prepared by the investigator. The
administration of the test was individual. The time limit was also informed to the testee. The investigator recorded all the steps performed by the testee and observed the testee carefully. During the administration of the test, a kit of TLM was provided to the testee. List of schools for pilot study is given in Appendix IV.

At the end of prescribe time, the test booklets along with kit was collected. The responses of testees were assessed as per scoring key and item-wise, competency-wise and field-wise scores were decided by the evaluator i.e. by the investigator. Item-wise scores earned by the each testee were entered in to computer and a spread sheet in excel was prepared. With the help of NRTVB software item analysis was done. Such analysis provides Difficulty Value (D.V) and Discriminative Index (D.I.). For each test and and for each item D.V. and D.I were computed. As per pre-decided specifications items were selected. At the end of Pilot study only 20, 14 and 12 items were selected for final test for Grade V, VI, VII respectively. These difficulty value and discrimination index of each items are given in Appendix V.

5.5.3 Final Run

The Object of the final run were

1. To find out Reliability and Validity of all the three tests.

2. To find out the Achievement level of the of the students Level wise, Grade wise, Area wise and Gender wise.

A test for final run was prepared with due instructions. The final tests are appended as Appendix VI. Also list of schools for final run are appended in Appendix-VII.

5.6.0 Process of Test Administration

Data collection for final run-out was made during the academic year 2011-12. Necessary copies of the test booklets with mathematical instruments were kept ready for administration to the students.

The investigator approached the DIET lecturer from selected districts and requested for the test administration well in advance and also for the re-test on the selected students after the lapse of fifteen days. List of Schools for Final Run was presented in Appendix-VII.
Proper supervision was made during the administration of the test and the Re-Test. In each case, at the end of 45 minutes the booklets were collected from the respondents.

5.6.1 Format of the tests

The structure of the test represents each competency number along with the respective items belonging to that competency: 6.5.10 “Draw the circle of radius 3 cm. having the centre P.” As only the three tests were included in Action-oriented Competency-based items, the students were required to give answer in the test paper itself with the help of Mathematical instruments. The investigator had provided the relevant mathematical kit, to each student taking the test.

5.6.2 Tool Kit

The Tool Kit includes following instruments.

(1) Abacus (2) Scale (3) Protractor (4) Compass (5) Set-squares (6) Graph papers (7) Specimen Cheques

The diagrams of Mathematical instruments used are shown in Appendix-VIII.

5.6.3 Length of the tests

Test of each grade contains various number of competencies and items. The test for Grade V contains five competencies with twenty items. Nine competencies with fourteen items were included in the test for Grade VI; while the test for Grade VII comprises three competencies with twelve items.

5.6.4 Time Duration

Each of the students taking the test belonging to the three grades V, VI and VII, was required to respond to the test items in forty five minutes.

5.6.5 Response sheet

There was no need for separate answer sheets for the concerned tests for grade V, VI and VII. Adequate space was provided for using the mathematical instruments in responding to the test.
5.6.6 Scoring Key

A key for scoring the responses of the respondents was used for scoring the response and allocating score for each answer sheets. The range of score for items selected in the test was 1 to 5. Each student taking the test was required to perform necessary actions to reach the final answer. The supervisor (here the investigator), had to observe the performance of the testee when he was trying to solve the item. In such situation a comprehensive scoring key was designed grade-wise and item-wise. During the performing Action, the following criteria were decided for scoring.

- If performed correctly, that is, passed through all the decided activities and reach to correct answer.-Full marks.
- If performed 75 percent stages correctly but could not complete fully-75 % marks.
- If performed 50 percent stages correctly but could not complete fully-50 % marks.
- If performed 25 percent stages correctly but could not complete fully-25 %
- If fails to perform all the stages – Zero mark

A detailed scoring key for every item of each test is given in as Appendix-IX.

5.7.0 Conclusion

The present tests are performance based and are meant for the students of Grade V, VI, VII. The abilities and limitations of the students were kept in a view while coining the items of the test. A detailed scoring key has not kept any room for the scores to be a lethargic. It provides total objectivity in scoring. It also provided situation for high scorer reliability. The final form was administered to 360 students from the population and Reliability and Validity were estimated on entire sample. The methods to find out Reliability and Validity of the test are explain in the following chapter.