CHAPTER V

RELIABILITY AND VALIDITY OF THE INSTRUMENTS

The reliabilities of the Mathematical Creativity Search (MCS) Battery, the Study Habits in Mathematics (SHM) Scale, and the Pupils' Perception of Teachers' Impressions about their Performance in Mathematics (PPTIPM) Scale were estimated using a sub-sample of 275 students. The sub-sample was administered all the three instruments twice at an interval of 10-15 days, and the two sets of measures obtained on each instrument for the subjects were utilised to compute the reliability coefficients. Both Analysis of Variance approach and Test-Retest method were used for this purpose.

Criterion-Related Validity coefficients were computed for all these three instruments, besides providing some evidence for their Construct Validity. A detailed description of the methods of estimating reliability and validity of the three tools used in the present study was given below.

5.1 Reliability of the MCS Battery

Two sets of composite Mathematical Creativity scores (sum of the fluency, flexibility and originality scores for all the four activities included in the Battery) were collected for the subjects of the sub-sample from the two administrations of the Mathematical Creativity Search (MCS)
Battery. The justification for using the composite creativity scores was provided by the statistically significant positive intercorrelations among the mathematical creativity measures (See Table 6.1). The two sets of mathematical creativity composite scores served as the basic data for estimating the reliability of the MCS Battery. The ANOVA approach and the Test-Retest method of estimating reliability were used. The computational procedures were as follows:

5.1-1 Reliability of the MCS Battery - Analysis of Variance Approach: The computational procedure suggested by Burroughs (1971) was followed for estimating the reliability of the MCS by the ANOVA approach. The sample for the ANOVA had 275 boys and girls. The prototype of the design for the ANOVA was given in Table 5.1-1 (See page 118).

In Table 5.1-1, the symbols $X_{1i}$ and $X_{12}$ represented the raw scores of subject 'i' on the 1st and 2nd testing respectively. The symbol $t_1$ represented the total score of subject 'i', i.e., $t_1 = X_{1i} + X_{12}$. The Mean score of the subject 'i' was represented by $m_1$, i.e., $m_1 = \frac{t_1}{2}$.

The symbol $T_1$ denoted the sum of the scores obtained on the 1st testing for $n=275$ subjects, i.e., $T_1 = \sum_{i=1}^{275} X_{1i}$. $M_1$ stood for the Mean score for the 1st testing and was given by, $M_1 = \frac{T_1}{n}$. 
Similarly $T_2$ and $M_2$ denoted the Total and Mean scores respectively for the second testing, i.e., $T_2 = \sum_{i=1}^{n=275} X_{12}^i$ and $M_2 = \frac{T_2}{n}$.

The symbol G.T. represented the total score of the sub-sample (n=275) for both the administrations of the MCS Battery. It was given by:

$$G.T. \text{(Grand Total)} = \sum_{i=1}^{275} X_{11}^i + \sum_{i=1}^{275} X_{12}^i .$$

The symbol G.M. stood for the General Mean of the 2n scores i.e., $G.M. = \frac{G.T.}{2n} = \frac{M_1 + M_2}{2}$.

Table 5.1-1

Prototype of the ANOVA design for estimating Reliability of the MCS Battery

<table>
<thead>
<tr>
<th>Subject</th>
<th>Score on 1st Testing</th>
<th>Score on 2nd Testing</th>
<th>Individual Total Score</th>
<th>Individual Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$X_{11}$</td>
<td>$X_{12}$</td>
<td>$t_1$</td>
<td>$m_1$</td>
</tr>
<tr>
<td>2</td>
<td>$X_{21}$</td>
<td>$X_{22}$</td>
<td>$t_2$</td>
<td>$m_2$</td>
</tr>
<tr>
<td>3</td>
<td>$X_{31}$</td>
<td>$X_{32}$</td>
<td>$t_3$</td>
<td>$m_3$</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>$X_{11}$</td>
<td>$X_{12}$</td>
<td>$t_1$</td>
<td>$m_1$</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>n</td>
<td>$X_{n1}$</td>
<td>$X_{n2}$</td>
<td>$t_n$</td>
<td>$m_n$</td>
</tr>
<tr>
<td>Total</td>
<td>$T_1$</td>
<td>$T_2$</td>
<td>G.T.</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>$M_1$</td>
<td>$M_2$</td>
<td>G.M.</td>
<td></td>
</tr>
</tbody>
</table>
Estimation of reliability of the MGS Battery by this process involved the following steps.

STEP 1: Computation of Total and Mean Scores: The first step was to compute the Total and Mean scores for each subject and for each testing. In addition, the Grand Total and Grand Mean for both the administrations of the MGS Battery were obtained. In this case,

\[ T_1 = 50306; M_1 = 182.9309, \text{i.e. 182.931} \]
\[ T_2 = 57528; M_2 = 209.1927, \text{i.e. 209.193} \]
\[ \text{G.T.} = 107834; \text{G.M.} = 196.0618, \text{i.e. 196.062} \]

STEP 2: Computation of Different Quantities and "Sums of Squares" and Degrees of Freedom: The following quantities needed in computing different "Sums of Squares" (SS) were then obtained.

(1) Correction Factor (C.F.) = (G.T.) \times (G.M.) = 21142149.708

(2) Sum of the Squares of all the 2n(2x275) scores:
\[ \sum \sum x^2 = \sum_{i=1}^{275} x_{11}^2 + \sum_{i=1}^{275} x_{12}^2 \]
\[ = 10921280 + 14023032 = 24944312 \]

(3) Sum of the products of the Total and Mean scores for the two tests:
\[ = (T_1 \times M_1) + (T_2 \times M_2) \]
\[ = (50306 \times 182.931) + (57528 \times 209.193) \]
\[ = 21235981.79 \]
(4) Sum of the products of individual Total and Mean

\[
\text{score} = \sum_{i=1}^{275} (t_i \times m_i) = 24373465.
\]

Using the above quantities the following SS were computed:

(5) Total Sum of Squares: \(SS_{\text{total}}\) = (2) - (1)

\[= 24944312 - 21142149.708 = 3802162.292\]

(6) Between Tests Sum of Squares \(SS_{b\cdot\text{tests}}\) = (3) - (1)

\[= 21236981.79 - 21142149.708 = 94832.082\]

(7) Within Tests Sum of Squares \(SS_{w\cdot\text{tests}}\) = (5) - (6)

\[= SS_{\text{total}} - SS_{b\cdot\text{tests}}\]

\[= 3802162.292 - 94832.082 = 3707330.21\]

(8) Between Individuals (Subjects) Sum of Squares \(SS_{b\cdot\text{subjects}}\) = (4) - (1)

\[= 24373465 - 21142149.708 = 3231315.292\]

(9) Error (Residual) Sum of Squares \(SS_{\text{error}}\)

\[= SS_{w\cdot\text{tests}} - SS_{b\cdot\text{subjects}} = (7) - (8)\]

\[= 3707330.21 - 3231315.292 = 476014.918\]

The degrees of freedom for the different "Sums of Squares" were obtained as follows:

The df for \(SS_{\text{total}} = \) (Total number of scores) - 1

\[= 2n - 1 = 549\]

The df for \(SS_{b\cdot\text{tests}} = \) (Total number of testings) - 1

\[= 2 - 1 = 1\]
The df for $SS_{\text{w. tests}} = df$ for $SS_{\text{total}} - df$ for $SS_{\text{b. tests}}$

$$= 549 - 1 = 548,$$ and

The df for $SS_{\text{b. subjects}} = (\text{Number of subjects}) - 1$

$$= 275 - 1 = 274 = df \text{ for } SS_{\text{error}}.$$

**STEP 3: Summary of Analysis of Variance:** A table showing the sources of variation, SS, df and MS were presented in Table 5.1-2.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Tests</td>
<td>94832.082</td>
<td>1</td>
<td>94832.082</td>
</tr>
<tr>
<td>Within Tests</td>
<td>370733.210</td>
<td>548</td>
<td></td>
</tr>
<tr>
<td>Between subjects</td>
<td>3231315.292</td>
<td>274</td>
<td>11793.12</td>
</tr>
<tr>
<td>Error</td>
<td>476014.918</td>
<td>274</td>
<td>1737.28</td>
</tr>
<tr>
<td>Total</td>
<td>3802162.292</td>
<td>549</td>
<td></td>
</tr>
</tbody>
</table>

**STEP 4: Computation of Coefficient of Reliability:** The coefficient of reliability ($r$) of the MCS Battery was computed by the formula,

$$r = 1 - \frac{MS_{\text{error}}}{MS_{\text{b. subjects}}} = 1 - \frac{1737.28}{11793.12}$$

$$= 1 - 0.147 = 0.853.$$
The obtained 'r' was tested for significance by a 't' test. The formula used for finding the 't' value was,

\[
t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}
\]

(Best, 1982)

The 't' was found to be 27.005. This value of 't' for \( n - 2 \) degrees of freedom was found to be statistically significant at the 0.001 level.

5.1-2 Test-Retest method of Estimating Reliability of the MCS Battery: The coefficient of reliability for the MCS Battery was also found by the Test-Retest method. The two sets of scores obtained from the two administrations of the Battery on the same sub-sample (n=275) were correlated, and the correlation coefficient (r) was computed by the following formula.

\[
r = \frac{\Sigma XY - N.M_XM_Y}{\sqrt{(\Sigma X^2 - NM_X^2)(\Sigma Y^2 - NM_Y^2)}}
\]

(Garrett, 1979)

Here, \( \Sigma XY \) = Sum of the Products of each subject's scores obtained for the two testings = 11901309

\( \Sigma X^2 \) = Sum of the squares of scores earned by the sub-sample on 1st testing = 10921280

\( \Sigma Y^2 \) = Sum of the squares of scores earned by the sub-sample on 2nd testing = 14023032

\( M_X \) = Mean score for the sub-sample on 1st testing

= 182.931
\[ M_Y = \text{Mean score for the sub-sample on 2nd testing} \]
\[ N = \text{Size of the sub-sample} = 275. \]

Substituting the values in the formula, 'r' was found to be 0.745. This value of 'r' was greater than the test-retest reliability coefficients reported by Singh (1981) and Zosa (1978) for their own Tests of Mathematical Creativity. The r's for their instruments were 0.63 and 0.70 respectively.

The reliability coefficients computed by either method were statistically significant. It was, therefore, concluded that the MCS Battery developed and used in this study was highly reliable.

5.2 Validity of the MCS Battery

This took the form of establishing Criterion-Related Validity and, to a limited extent, Construct Validity of the MCS Battery.

5.2-1 Estimation of Criterion-Related Validity of the MCS Battery

Achievement scores in mathematics, which were collected from school records for the subjects (N=585), were used as the criterion in determining this type of validity. The composite creativity scores earned by the subjects on each activity and on the whole Battery were correlated with the criterion measures. The correlation
coefficients so obtained were presented in Table 5.2-1.

Table 5.2-1

Correlation Coefficients between MCS Composite Creativity scores and Achievement scores in Mathematics (N=585)

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Variables</th>
<th>Correlation</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Composite score on MCS Activity 1 versus Achievement in Mathematics</td>
<td>0.415</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2.</td>
<td>Composite score on MCS Activity 2 versus Achievement in Mathematics</td>
<td>0.365</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3.</td>
<td>Composite score on MCS Activity 3 versus Achievement in Mathematics</td>
<td>0.439</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4.</td>
<td>Composite score on MCS Activity 4 versus Achievement in Mathematics</td>
<td>0.526</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>5.</td>
<td>Composite score on the whole MCS Battery versus Achievement in Mathematics</td>
<td>0.554</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

The above Table revealed that all the coefficients of correlation were significant at 0.001 level, and supported the earlier findings on the relationship between Mathematical Creativity and Mathematics Achievement (Swain, 1982; Tuli, 1984; Evans, 1965; Banghart & Spraker, 1963; Spraker, 1961). The observed relationship between the two variables, however, contradicted Mainville (1972) who reported non-significant relationship, and Balka (1975) and Jensen (1973) who found low relationship between them. The significant and positive
moderate relationship between the set of creativity scores provided by the MGS Battery, as a whole, and the set of achievement scores in mathematics ($r=0.55$) indicated that the newly developed instrument had the potential to predict achievement in mathematics. Thus, the MGS Battery was found to be valid enough to warrant its use.

5.2-2 Estimation of Construct Validity of the MGS Battery:
It was desired to obtain evidence for the assumption (underlying the construction of the MGS Battery) that fluency, flexibility and originality, the three facets of creative ability in mathematics, were related to each other. Correlations among the fluency, flexibility and originality scores obtained for the entire sample ($N=585$) within each activity and between different activities included in the Battery were computed. Each of those three measures was also correlated with the composite creativity scores of the subjects on the whole Battery. All the intra- and inter-correlations among those three measures, and correlation of each of those with the composite creativity score on the Battery (presented in Table 6.1) were found to be positive and statistically significant.

Furthermore, correlation coefficients among the composite creativity scores on different activities, and between the composite creativity score on each activity and on the whole Battery were determined to test the hypothesis that the abilities measured by them were related. Those correlation
coefficients were given in Table 5.2-2.

Table 5.2-2

Inter-Correlations among the Composite Creativity Scores on Different Activities of the MCS Battery

<table>
<thead>
<tr>
<th></th>
<th>Activity 1</th>
<th>Activity 2</th>
<th>Activity 3</th>
<th>Activity 4</th>
<th>Total Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1</td>
<td>-</td>
<td>0.413*</td>
<td>0.429*</td>
<td>0.404*</td>
<td>0.861*</td>
</tr>
<tr>
<td>Activity 2</td>
<td>-</td>
<td>-</td>
<td>0.418*</td>
<td>0.317*</td>
<td>0.756*</td>
</tr>
<tr>
<td>Activity 3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.477*</td>
<td>0.666*</td>
</tr>
<tr>
<td>Activity 4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.609*</td>
</tr>
</tbody>
</table>

(* significant at the 0.001 level)

All the Correlation Coefficients were found to be statistically significant ($P<0.001$). In view of all such statistical evidences it was concluded that the MCS Battery had Construct Validity.

5.3 Reliability of the SHM Scale:

The reliability of the SHM Scale was determined through the Analysis of Variance and Test-Retest methods. The Test-Retest scores on SHM of the sub-sample ($n=275$) were utilised for this purpose. The procedure followed in computing the correlation coefficients were described below.
5.3.1 ANOVA Approach to the Reliability of the SHM Scale:

The computational procedures were the same as those followed in determining the reliability coefficient of the MCS Battery through this method. For the Study Habits in Mathematics (SHM) Scale, different quantities and "Sums of Squares", as obtained from basic data were:

\[ T_1 = 43881; M_1 = 159.567 \]
\[ T_2 = 43629; M_2 = 158.651 \]
\[ G.T. = 87510; G.M. = 159.109 \]

(1) Correction Factor (C.F.) = 1392362.59

(2) Sum of the Squares of all the 2n scores:
\[ \sum \sum x^2 = 14293438 \]

(3) Sum of the products of the Total and Mean scores for the two tests = \((T_1 \times M_1) + (T_2 \times M_2)\)
\[ = 13923744.01 \]

(4) Sum of the products of individual Total and Mean score = \(\frac{275}{n} (t_1 \times m_1) = 14241879 \)

(5) Total Sum of Squares (SS_{total}) = (2) - (1)
\[ = 369809.41 \]

(6) Between Tests Sum of Squares (SS_{b. tests}) = (3) - (1)
\[ = 115.42 \]
(7) Within Tests Sum of Squares \((SS_{w\text{-tests}})\) = (5) - (6)
\[ = 369693.99 \]

(8) Between Individuals (Subjects) Sum of Squares 
\((SS_{b\text{-subjects}}) = (4) - (1)\)
\[ = 318250.41 \]

(9) Error (Residual) Sum of Squares \((SS_{\text{error}})\)
\[ = SS_{w\text{-tests}} - SS_{b\text{-subjects}} = (7) - (8) \]
\[ = 51443.58 \]

Different "Sums of Squares" had the same number of df as the corresponding "Sum of Squares" for the MCS Battery. A summary of the Analysis of Variance was tabulated as shown in Table 5.3-1.

Table 5.3-1

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Tests</td>
<td>115.42</td>
<td>1</td>
<td>115.42</td>
</tr>
<tr>
<td>Within Tests</td>
<td>369693.99</td>
<td>548</td>
<td></td>
</tr>
<tr>
<td>Between Subjects</td>
<td>318250.41</td>
<td>274</td>
<td>1161.4978</td>
</tr>
<tr>
<td>Error</td>
<td>51443.58</td>
<td>274</td>
<td>187.7503</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>369809.41</strong></td>
<td><strong>549</strong></td>
<td></td>
</tr>
</tbody>
</table>

The reliability coefficient of the SHM Scale was,
A t-test was applied to determine the significance of the obtained 'r'. The t-value corresponding to $r = 0.838$ was computed by the formula,

$$t = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}}$$

The t was found to be statistically significant at the 0.001 level. Thus, the SHM Scale was found highly reliable.

5.3.2 Test-Retest method of Estimating Reliability of the SHM Scale: The Test-Retest reliability coefficient was given by the formula,

$$r = \frac{\sum XY - NM_X M_Y}{\sqrt{\left(\sum X^2 - N M_X^2\right) \left(\sum Y^2 - N M_Y^2\right)}}$$

For this Scale, the following were the values for different quantities used in the formula.

- $\sum XY = 7095160$,
- $\sum X^2 = 7178227$,
- $\sum Y^2 = 7115211$,
- $M_X = 159.567$,
- $M_Y = 158.651$, and
- $N = 275$.

Putting those values in the formula given above, $r$ was found to be 0.722. A comparison of this reliability
coefficient with the Test-Retest reliability coefficients reported by Sinha (1972) and Polk (1965) for their general Study Habits and Attitude Inventory and Study Skills Check-list (r=0.61 and r=0.75) respectively supported the claim that the newly constructed SMH Scale used in this study is reliable for obtaining measures of Study Habits in Mathematics.

The significant reliability coefficients obtained through both the methods established that the SMH Scale is reliable enough for use in the present study.

5.4 Validity of the SHM Scale

As in the case of the MCS Battery, Criterion-Related Validity and Construct Validity were estimated for the SHM Scale. The method of establishing the Construct Validity of this instrument was, however, different from that used in the former case. A detailed description about the method of determining each type of validity was given below.

5.4-1 Estimation of Criterion-Related Validity of the SHM Scale: The criterion measure used in this study for estimating this type of validity was Mathematics Achievement. Scores earned by the sample on the Study Habits in Mathematics (SMH) Scale were correlated with the criterion measure. The formula used in correlating the two sets of scores was:

\[
 r = \frac{\sum XY - NM_XM_Y}{\sqrt{\left(\sum X^2 - NM_X^2\right)\left(\sum Y^2 - NM_Y^2\right)} }
\]
The correlation coefficient \( (r) \) was found to be 0.344. The 'r' so obtained was tested for significance by the 't' test. The 't' was given by the formula:

\[
    t = \frac{r \sqrt{N-2}}{\sqrt{1 - r^2}} \quad \text{(Best, 1982)}
\]

The t-critical value so obtained came to \( 8.845 \) with \( df = 583 \). This t-critical value was found to be significant at the 0.001 level, since t-critical value \( (0.001, \infty) = 3.291 \). It was, thus established that scores on the SHM Scale were significantly and positively correlated with achievement scores in mathematics. This pointed to the Criterion Validity of the SHM Scale. This finding was in agreement with those reported by Routray (1983), Tuli (1980) and Lalithama (1975) in their studies. Furthermore, several investigators (Sinha, 1972; Polk, 1965; Brown and Holtzman, 1955; Carter, 1950; Wrenn and Larsen, 1941) reported the correlation coefficients between the measures on general Study Habits/Study Habits and Attitude Inventory and scholastic achievement measures/examination grades/grade point average. Those correlation Coefficients ranged from 0.33 to 0.65.

5.4-2 Estimation of Construct Validity of the SHM Scale: The Construct Validity of the SHM Scale was determined through comparison of known groups (Gronlund, 1976). It was predicted that this instrument would effectively differentiate
subjects belonging to different achievement levels in mathematics. To test the accuracy of this prediction, the total sample \((N=535)\) were divided into three groups: high, average, and low, on the basis of achievement scores in mathematics. Those whose mathematics scores were \((M+10)\) or above in the distribution of mathematics scores were designated as "high-achievers". There were 106 subjects in this high-achievers group. Subjects who scored \((M-10)\) or less were called "low-achievers". There were 109 subjects in this group. The remaining 370 subjects belonged to the "average-achievers" group. For each group the mean and SD of the distribution of SHM scores were computed.

**Table 5.4-2**

Means & Standard Deviations for the SHM Scores of the High, Average & Low Achievers

<table>
<thead>
<tr>
<th>Statistic</th>
<th>High Achievers ((N=106))</th>
<th>Average Achievers ((N=370))</th>
<th>Low Achievers ((N=109))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>172.66 ((M_1))</td>
<td>158.85 ((M_2))</td>
<td>149.17 ((M_3))</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>19.26 ((\sigma_1))</td>
<td>22.28 ((\sigma_2))</td>
<td>22.64 ((\sigma_3))</td>
</tr>
</tbody>
</table>

The difference between each pair of the three means, so obtained was tested for significance by computing the Critical Ratios. The formula used for computing the
Critical Ratios was:

\[ CR = \frac{M_1 - M_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}} \]

where, \(M_1, \sigma_1,\) and \(N_1\) represented respectively the Mean, SD, and size of Group 1; and \(M_2, \sigma_2,\) and \(N_2\) stood for the Mean, SD, and size respectively of Group 2.

The Critical Ratios for the difference between the Mean SHM Scores of the three groups were given in Table 5.4-2(A).

Table 5.4-2(A)

CRs for the Comparison of the SHM Scores of High, Average & Low Achievers in Mathematics

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Comparison Groups</th>
<th>CR</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High versus Average</td>
<td>6.28</td>
<td>(&lt;0.01</td>
</tr>
<tr>
<td>2</td>
<td>High versus Low</td>
<td>8.21</td>
<td>(&lt;0.01</td>
</tr>
<tr>
<td>3</td>
<td>Average versus Low</td>
<td>3.93</td>
<td>(&lt;0.01</td>
</tr>
</tbody>
</table>

All the Critical Ratios were significant at the 0.01 level. The significant Critical Ratios supported the prediction that the SHM Scale was an efficient tool to differentiate different achievement categories in mathematics. The higher the score on the SHM Scale the
better is the achievement in mathematics. This pointed to the Construct Validity of the SHM Scale.

5.5 Reliability of the PPTIPM Scale:

The reliability of the Pupils' Perception of Teachers' Impressions about their Performance in Mathematics (PPTIPM) Scale was estimated through the same methods and procedures as employed in the case of the other two instruments. Reliability coefficients were computed in the following manner:

5.5.1 Analysis of Variance Approach to Reliability of PPTIPM Scale: Scores obtained from both the administrations of the Scale on the sub-sample (N=275) were used in computing different quantities and "Sums of Squares" as given below:

\[ T_1 = 37005; \quad M_1 = 134.5636 \]
\[ T_2 = 37568; \quad M_2 = 136.6109 \]
\[ G.T. = 74573; \quad G.M. = 135.5873 \]

(1) Correction Factor (C.F.) = 10111151.7229

(2) Sum of the Squares of all the 2n scores
\[ \Sigma \Sigma x^2 = 10464254 \]

(3) Sum of the products of the Total and Mean scores for the two tests \[ (T_1 \times M_1) + (T_2 \times M_2) \]
\[ = 10111724.3092 \]
(4) Sum of the products of individual Total and Mean score
\[ \sum_{i=1}^{n} (t_i \times m_i) = 10430010 \]

(5) Total Sum of Squares \( (SS_{total}) = (2) - (1) \)
\[ = 353102.277 \text{, or } 353102.277 \]

(6) Between Tests Sum of Squares \( (SS_{b.tests}) = (3) - (1) \)
\[ = 572.5863 \text{, or } 572.586 \]

(7) Within Tests Sum of Squares \( (SS_{w.tests}) = (5) - (6) \)
\[ = 352529.691 \]

(8) Between Individuals (Subjects) Sum of Squares
\( (SS_{b.subjects}) = (4) - (1) \)
\[ = 318858.277 \text{, or } 318858.277 \]

(9) Error (Residual) Sum of Squares \( (SS_{error}) \)
\[ = SS_{w.tests} - SS_{b.subjects} = (7) - (8) \]
\[ = 33671.414 \]

A summary of the Analysis of Variance was prepared as shown in Table 5.5-1.

Table 5.5-1

Summary of ANOVA for Estimating Reliability of the PPTIPM Scale

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Tests</td>
<td>572.586</td>
<td>1</td>
<td>572.586</td>
</tr>
<tr>
<td>Within Tests</td>
<td>352529.691</td>
<td>548</td>
<td></td>
</tr>
<tr>
<td>Between Subjects</td>
<td>318858.277</td>
<td>274</td>
<td>1163.716</td>
</tr>
<tr>
<td>Error</td>
<td>33671.414</td>
<td>274</td>
<td>122.888</td>
</tr>
<tr>
<td>Total</td>
<td>353102.277</td>
<td>549</td>
<td></td>
</tr>
</tbody>
</table>
The reliability coefficient of the PPTIPM Scale was,

\[ r = 1 - \frac{122.888}{1163.716} = 1 - 0.106 = 0.894 \]

This reliability coefficient was quite high, and this pointed to the reliability of the PPTIPM Scale.

5.5.2 Test-Retest method of Estimating Reliability of the PPTIPM Scale: Two sets of scores obtained from the administration of this Scale twice to the same sub-sample were correlated using the formula,

\[ r = \frac{\sum XY - NM_X M_Y}{\sqrt{(\sum X^2 - NM_X^2)(\sum Y^2 - NM_Y^2)}} \]

Different quantities used in the above formula were found and substituted. For this Scale those quantities were as follows:

\[ \sum XY = 519783, \]
\[ \sum X^2 = 5137599, \]
\[ \sum Y^2 = 5326655, \]
\[ M_X = 134.5636, \]
\[ M_Y = 136.6109, \text{ and} \]
\[ N = 275. \]

The reliability coefficient (r) so obtained was 0.813. This 'r' was very close to the Test-Retest reliability coefficient (\( \rho = 0.85 \)) reported by Davidson and Lang (1962)
for their Check-list of trait names which measured children’s perception of their teachers’ feelings towards them.

The reliability coefficients computed through both the methods were quite high and thus the PPTIPM Scale used in this study was highly reliable.

5.6 Validity of the PPTIPM Scale:

The validity of this instrument was established through estimation of both Criterion-Related Validity and Construct Validity. The validation procedures were described below.

5.6-1 Estimation of Criterion-Related Validity of the PPTIPM Scale: In estimating Criterion-Related validity for the PPTIPM Scale, scores earned by the subjects of the entire sample (N=585) on this instrument were correlated with their Mathematics Achievement scores collected from school records. These two sets of scores were correlated by the formula,

\[ r = \frac{\sum XY - N \bar{X} \bar{Y}}{\sqrt{\left( \sum X^2 - N \bar{X}^2 \right) \left( \sum Y^2 - N \bar{Y}^2 \right)}} \]

A correlation coefficient of \( r = 0.372 \) was obtained. This \( r \) was tested for significance by the \( t \) test. The \( t \) is given by,

\[ t = \frac{r \sqrt{N-2}}{\sqrt{1-r^2}} \]

This \( t \)-critical value for 583 df was 9.680, and it was
significant at the 0.001 level \( t_{.999} (\infty) = 3.291 \). This significant 't' pointed to the Criterion Validity of the PPTIPM Scale.

5.6-2 Estimation of Construct Validity of the PPTIPM Scale: The procedures of construct validation of the SHM Scale was adopted in this case. The three achievement groups - "High Achievers" (Group 1), "Average Achievers" (Group 2) and "Low Achievers" (Group 3) were constituted on the basis of Mathematics Achievement. The procedure for constituting these groups was the same as that described earlier. The performance of these groups on the PPTIPM measure was compared by Critical Ratios. The Means and SDs of these groups for PPTIPM measures were computed and given in Table 5.6-2.

Table 5.6-2

<table>
<thead>
<tr>
<th>Statistic</th>
<th>High Achievers (N=106)</th>
<th>Average Achievers (N=370)</th>
<th>Low Achievers (N=109)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>150.23 (( M_1 ))</td>
<td>133.60 (( M_2 ))</td>
<td>124.15 (( M_3 ))</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>20.97 (( \sigma_1 ))</td>
<td>23.92 (( \sigma_2 ))</td>
<td>21.47 (( \sigma_3 ))</td>
</tr>
</tbody>
</table>
Critical Ratio (CR) for the difference between each pair of these three Means was computed. These CRs were given in Table 5.6-2 (A).

Table 5.6-2(A)

CRs for the Comparison of the PPTIPM Scores of High, Average & Low Achievers in Mathematics

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Comparison Groups</th>
<th>CR</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High versus Average</td>
<td>6.96</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>2</td>
<td>High versus Low</td>
<td>9.02</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>3</td>
<td>Average versus Low</td>
<td>3.94</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

All the three Critical Ratios were found to be significant at the 0.01 level. Those significant CRs indicated that the observed difference between each pair of Means was not attributable to sampling error. In other words, there was significant difference among the three different groups of achievers in mathematics in their performance on the PPTIPM Scale. The higher the score on the PPTIPM Scale, the better was the achievement in mathematics. This pointed to the Construct Validity of the Scale.

In summary, the MGS Battery and the SHM and PPTIPM Scales used in the study were found to be reliable and valid.