CHAPTER SIX

SUMMARY AND CONCLUSIONS
CHAPTER SIX
SUMMARY AND CONCLUSIONS

The study entitled, "Mathematical Creativity as Related to Aptitude for, Achievement in, and Attitude Towards Mathematics" was aimed at exploring the nature of creative ability in mathematics and determining its relationship with aptitude for, achievement in, and attitudes towards mathematics for high/higher secondary school students.

The recognition and demand for the creative individual's contribution to society, the movement for educational equality, disenchantment with intelligence tests and subsequent search for alternative measure of functioning have resulted in great demand on research on creative talent. The knowledge of creativity is important in education programming, especially in mathematics where many students encounter difficulties. Creativity in mathematics has been of vital importance in promoting progress of human civilisation.

In view of importance of mathematical creativity and research findings it appeared logical that its nature, nurture and utilisation may be explored with great rigour.
The following research issues emanated after a systematic sifting of relevant research studies:

- Whether mathematical creativity and aptitude for mathematics are two distinguishable modes of the same cognitive functioning.

- Whether mathematical creativity and attitude towards mathematics are independent of each other.

- Whether mathematical creativity and achievement in mathematics are independent of each other.

The hypotheses examined for various issues raised above were:

- Mathematical creativity is significantly related to aptitude for mathematics.

- Significant relationship exists between mathematical creativity and attitude towards mathematics.

- Mathematical creativity contributes significantly towards achievement in mathematics.

- Aptitude for mathematics and attitude towards mathematics conjointly contribute to mathematical creativity.
The nature of this investigation led to conduct a survey to establish bivariate and multivariate relationships involved in the study. The survey method was employed to investigate such relationships.

The study was conducted on a sample drawn from the 9th grade high/higher secondary school students of Punjab State. The sample was selected by employing the technique of multistaged randomization of clusters at district, block and school levels.

The research tools administered to each subject consisted of Balka's (1974) Creative Ability in Mathematics Test (CAMT) translated by the investigator in Hindi and adapted for local use; The Numerical Ability Test (NA), Verbal Reasoning Test (VR), Abstract Reasoning Test (AR), of Revision of Differential Aptitude for Higher Secondary Schools (The Hindi adaptation of the Form L of the Well known battery of Differential Aptitude Tests prepared by Drs. Bennet, Wesman and Seashore) by J.M. Ojha and Mathematics Attitude Scale (MAS) developed and validated by the investigator himself.

The data yielded scores for the variables of aptitude for mathematics, achievement, attitude towards mathematics and creative ability in mathematics. The statistical analysis included descriptive statistics for
studying the nature of different variables. Factor-analysis by principal-component method and varimax rotation were carried to identify factor structure of mathematical creativity. The regression analysis technique - $\beta$-Weights step-up equation was used to investigate contribution of each predictor to the criterion variables of mathematical creativity.

The assessment data consisted of pupil's performance on a series of tasks that is Numerical Ability Test (NA), Verbal Reasoning Test (VR), Abstract Reasoning Test (AR), Mathematics Attitude Scale (MAS), Creative Ability Test (CAMT) and School Board Examination Marks in Mathematics. The tests were administered to all the students included in the sample. The testing took place in two sessions of 1½ hours each.

The data yielded scores on the following variables:

The aptitude for mathematics i.e.

a) Numerical Ability Score (NA)
b) Verbal Reasoning Score (VR)
c) Abstract Reasoning Score (AR)
d) General Ability Score (GA) i.e. (NA Score + VR Score + AR Score).

Achievement Scores

a) Achievement in mathematics was the score obtained by the student in mathematics in 8th grade examination of Punjab School Board.
b) Academic achievement was the aggregate score obtained by the student in 8th grade examination of Punjab School Board.

The attitude towards mathematics was the score obtained by the student on Mathematics Attitude Scale (MAS).

The creative ability in mathematics included the following scores on CAMT:

a) Fluency score 
b) Flexibility score 
c) Originality score 
d) Creative Ability in Mathematics score

(Fluency Score + Flexibility Score + Originality Score).

The criterion variables were fluency, flexibility, originality and total (Fluency + Flexibility + Originality on CAMT) and predictors variables were MAS, achievement in mathematics, academic achievement, aptitude for mathematics i.e. NA, VR, AR and CA.

A factorial analysis involving $\frac{11 \times 10}{2}$ correlations was determined to identify factor structure of mathematical creativity. The data were further subjected to regression analysis to determine the contribution of each of the independent variables to criterion variables. Four different analyses were -
— fluency was criterion and each one of
the predictors was used for stepping-up,

— flexibility was criterion and each one
of the predictors was used for stepping-up,

— originality was criterion and each one
of the predictors was used for stepping-up, and

— the CAMT (fluency + flexibility + originality)
was criterion and each one of the predictors
was used for stepping up were carried out.

There was a dearth of relevant and valid instruments
to measure attitude towards mathematics. Therefore, the
MAS (Mathematics Attitude Scale) was locally developed for
school population. The 'Scale-Product Method' of scale
construction was employed. The preliminary draft of the
scale consisted of 112 statements reflecting attitude
towards mathematics i.e. nature of mathematics, values
and utility of mathematics, and experience with mathematics.
The sixty (60) judges were requested to evaluate each
statement on a nine point scale ranging from one extreme of
the continuum to the other. The obtained scale values
ranged from 1.109 to 8.66 and Q values from .61 to
5.475. Forty three statements were selected whose Q values
were less than 2.
The scale construction took place on a population (boys and girls) of 9th class of high and higher secondary school of Punjab State. Item analysis was computed to determine as to how well the scale items differentiate between the criterion groups based on total scores. The biserial r and phi-coefficient were chosen for item analysis. The statements having significant (i.e. \( Z^2 \) at .05 and .01) were retained. The MAS consisted of 32 statements (nature of mathematics - Statement no. 1,2,3,4,7, 8, 9, 25, 26, 30; utility of mathematics - S.no. 5, 6, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 and experience - interaction with mathematics - S.no. 23, 24, 27, 28, 29, 31, 32) finally (Refer Appendix C).

The test-retest and split half reliability were determined on one hundred (100) subjects for the MAS. It were found to be .85 and .89 respectively.

The factor analysis technique of principal components was employed to determine validity and factor structure of mathematics attitude scale (MAS). It was observed from the correlation-matrix that positive significant correlations exist among different areas of attitude scale at .01 level.

The principal components analysis explicited four factors. The first factor extracted was multi-dimensional
factor consisting of nature of mathematics, utility of mathematics, experience with mathematics and total i.e. composite score. It was identified as a 'General factor of attitude towards mathematics'. It proved that the MAS enjoys high internal consistency and construct validity. The second factor was a 'Factor of attitude toward experience with mathematics.' The third factor extracted was called a 'Factor of attitude towards nature of mathematics'. The fourth factor was identified as a 'Factor of attitude towards utility of mathematics'.

It was inferred from the findings given above that the MAS enjoys high factorial validity. The factorial validity of the MAS was further confirmed with a large sample in Chapter 5.

The Creative Ability in Mathematics

Test (CAMT) developed by Balka (1974) for measuring creative ability in mathematics at the Junior High School level was adapted for local use. It was translated into Hindi with the help of experts. The factor-analysis in chapter fifth confirmed validity of the CAMT for the local population.

After having finalised the research tools, it were administered to a sample of 1000 pupils from the
schools of Punjab state by employing the technique of multistage randomization of clusters at district, block and school levels. Finally, only 915 cases were effectively involved in the study and others had to be deleted due to incomplete information.

The factor analysis technique of principal component was used to identify factor structure of mathematical creativity and to test hypotheses. The correlation-matrix of criterion and predictor variables revealed that there is a significant positive correlation between aptitude for mathematics and mathematical creativity at .01 level. The achievements in mathematics and academic achievement were found to be significantly positively related to mathematical creativity at .01 level. However, the correlations between attitude towards mathematics and criterion variables were not significant, either at .01 or .05 level. The relationships were found to be differential with respect to areas of creativity in mathematics.

The principal components analysis explicited five factors. The first factor extracted was multidimensional single pole factor consisting of numerical ability, verbal reasoning, abstract reasoning, general ability, achievement in mathematics, academic achievement, creative abilities in mathematics — fluency, flexibility, originality and composite score of fluency, flexibility and originality.
It was named as a 'General factor of cognition'. It proved the thesis that mathematical creativity is related to aptitude for mathematics and achievement in mathematics. However, the General factor of cognition was found to be independent of attitude towards mathematics.

The second factor was bipolar with positive loadings on convergent products versus negative loadings on divergent products. It was identified as a factor of 'Intellective Styles'. It proved that aptitude for mathematics and creative abilities in mathematics lie on the same continuum but on opposite pole. These are functions of the same intellective style, but high aptitude for mathematics does not imply great creativeness in mathematics.

The third factor was that of 'Attitude towards Mathematics' which shared commonness with numerical ability. It was independent of creative abilities in mathematics.

The fourth factor was that of 'academic achievement' which shared common loadings with achievement in maths, and abstract reasoning. The abstract reasoning and achievement in mathematics are essential ingradient of total academic excellence.

The fifth factor was bipolar in nature and was identified as a 'Specific factor of achievement in mathematics' with positive loadings on convergent solutions.
and negative loadings on divergent solutions. The numerical ability, which is an essential ingredient of achievement in mathematics lies with originality on the same continuum but with opposite polarity.

The attitude was independent of creative abilities in mathematics and aptitude for mathematics. It implies that a person with positive attitude towards mathematics shall not necessarily be creative in mathematics. Thus, the hypothesis that mathematical creativity is related to attitude towards mathematics stands rejected.

The data were further subjected to regression analysis to determine the contribution of each of independent variables to criterion variables. The regression equations step-up $B$-weights were determined to know the contribution of predictors to the criterion variables. Four different analyses were carried out when:

- fluency was the criterion and each one of the predictors was used for stepping up,
- flexibility was the criterion and each one of the predictors was used for stepping-up,
- originality was the criterion and each one of the predictors was used for stepping up, and
- the CAMT (fluency + flexibility + originality) was the criterion and each one of the predictors was used for stepping-up.
All multiple correlations $R$ were significant at .01 level.

It was inferred that academic achievement and attitude towards mathematics did not significantly predict creative ability in mathematics (fluency). However, aptitude for mathematics and achievement in mathematics predict creative ability of fluency in mathematics.

The aptitude for mathematics and achievement in mathematics predicted creative ability of flexibility in mathematics whereas attitude towards mathematics and academic achievement did not predict it significantly.

The achievement and attitude towards mathematics were not significant predictors of creative ability of originality in mathematics whereas aptitude for mathematics was found to predict it.

The aptitude for mathematics and achievement in mathematics were found to be significant predictors of creative ability in mathematics (composite score of fluency, flexibility and originality) at .01 level. The attitude towards mathematics and academic achievement did not predict it.

Thus, it was inferred that aptitude for mathematics and achievement in mathematics were predictors of creative abilities in mathematics whereas attitude towards mathematics and academic achievement did not reveal creative
potentialities. The predictions of predictors were differential with respect to areas of creativity in mathematics.

The findings of this study support the hypothesis that mathematical creativity is significantly related to aptitude for mathematics. Although, mathematical creativity and aptitude for mathematics lie on the same continuum but are on opposite poles—one is more akin to divergent production, and other to convergent production.

The hypothesis that significant relationship exists between mathematical creativity and attitude towards mathematics did not hold tenable. The attitude towards mathematics was not found to be predictor of creative ability in mathematics in the present study.

The study supports the hypothesis that achievement in mathematics is significantly related with creative abilities in mathematics.

The hypothesis that aptitude for mathematics and attitude towards mathematics conjointly contribute to mathematical creativity stands rejected.

The findings of the study confirm the
hypotheses that —

— mathematical creativity is significantly related to aptitude for mathematics; and

— mathematical creativity contributes significantly towards achievement in mathematics.

However, the investigation refutes the hypotheses that —

— significant relationship exists between mathematical creativity and attitude towards mathematics; and

— aptitude for mathematics and attitude towards mathematics conjointly contribute to mathematical creativity.