FOSTERING MATHEMATICAL CREATIVITY

Dr. Lalit Kumar
Faculty of Education
Patna University, Patna

Creativity and Mathematical Creativity

There is no uniformly in various definitions of creativity. It has been defined differently and it has not any universally accepted definition as such. K. Benett has done research on the meaning of creativity. According to him creativity is multidimensional and its meaning is not same for all people. It does not have a universally accepted definition, though there is similarity in various definitions of it. There are some properties commonly related to it, such as Fluency, Flexibility, Divergent Thinking, Originality, Inventiveness, etc. Taylor identifies five types of creativity each with its own psychological process. These are : (1) Expressive creativity, in which originality and quality of product is unimportant; (2) Technical or Productive : This is concerned with skill rather than novelty; (3) Inventive : This form consists mainly of ingenuity leading to the production of a novel and appropriate product; (4) Innovative : This brings further development to an established body of meaning;

and (5) Emergentive, the final and most complex form of creativity. It is individualistic and results in highly generative insights. Creativity has many dimensions and as such we can call it as different types too. Mathematical creativity is one of the types of creativity related to original expression in mathematical field.

Out of a series of definitions of creativity I find Barron (1961)'s definition as the most simple – creativity means to make new combinations from already existing objectives and elements. Definition of Gruilford (1955) is important in the sense it distinguishes two types of thinking - creativity is identified as the process by distinguishing divergent thinking behaviour from convergent thinking. Khatena, Joe (1988) has concluded that of the many definition of creativity, the two which have been most productive to instrument development are Gruilford and Torrance. If we try to sense mathematical creativity on the line of above mentioned two definitions of creativity we can conclude mathematical creativity as to making new mathematical combinations from existing mathematical concepts, objects and elements. Divergent Thinking Pattern applied in the mathematics is

mathematical creativity as Gruilford has considered divergent thinking as creativity and convergent thinking as Intelligence. Creativity is a complex trait to identify in general and becomes even more difficult when we search for creativity within a subject area such as mathematics. J.N. Kapur has defined it as – mathematical creativity expresses itself in generating new significant concept, generalizing a number of concepts or theorems, establishing connections between obviously unconnected concepts and theorems and establishing connects between facts of mathematics and facts of nature of society. The most simple way as I think to define creativity or mathematical creativity is in terms of its measurement. Creativity is the sum total of scores on fluency (All the relevant responses), Flexibility (Number of Approaches/way adopted to respond) and originality (Peculiar, New and Unique responses). Infact Originality is the culmination point of the concept.

Measuring Creativity and Mathematical Creativity

There are certain qualities which can be taken into consideration with regard to creativity as Fluency, Flexibility, Originalilty and Elaboration. Fluency is

represented by the number of relevant and unrepeated ideas which the testee produces. Relevance is judged on the basis of the appropriateness of the response when considered in relation to the test problem. Flexibility is represented by a person's ability to produce ideas which differ in a approach or thought trend. All ideas which differ in approach or thought trend are treated as one for purpose of flexibility scoring. Thus if 5 ideas are produced and all belong to one category of approach or thought trend, the score for flexibility will be one, but if all the five ideas are based on 5 different approaches or thought trends, then the flexibility score will be five. Originality is represented by uncommonness of a given response. Response given by less than 5% of the group are treated as original. Elaboration is represented by a person's ability to add pertinent details (more ideas) to the minimum and primary responses to the stimulus figure. The minimum and primary response to the stimulus figure is that response which gives essential meaning to the picture. Dr. Mehdi in his test of verbal creativity has taken four types of works as Consequences Test, Unusual Uses Test, New Relationship Test and

Product Improvement Test to measure general creativity; Mathematical creativity Test may be developed on this pattern by selecting items from the mathematics content. Works selected by Dr. Mehdi is on the line of different activities included in the creativity tests of Gruilford, Torrance and Mednick.

Prof. Bhoodev Singh has developed and standardized mathematical creativity Test. It has verbal and Non-verbal works in the same test and so can be called verbal and non-verbal mathematical creativity Test. In the test the situations are real and provide a chance for the student to think and utilize his mathematical talent to the maximum possible extent. The verbal form of the test is composed of two activities, i.e., patterns in Mathematics and a New Relationship Test Activity of three items each. The non-verbal form of the test is composed of one activity, i.e. Incomplete mathematical figures of three items. Work one and two yield scores on the three creative ability measures of verbal fluency, verbal flexibility and verbal originality. The work three yields scores on the two mathematical creativity ability measures of Non-Verbal Elaboration and Non-Verbal

Originality. From the above discussions it is quite clear that measurement of creativity and mathematical creativity is difficult in comparison to other psychological traits and again it needs expertise. To understand the measurement of mathematical creativity it is relevant to mention the measuring activities developed by Balka and pronounced by Singh, Bhoodev (2003) through his comprehensive research paper published in the very prestigious NCERT Journal-Indian Educational Review, "Balka has developed the following criteria for measuring creative ability in Maths :

(1) The ability to formulate mathematical hypotheses concerning cause and effect in a mathematical situation.

(2) The ability to determine patterns in mathematical situations.

(3) The ability to break from established mind sets to obtained solutions in a mathematical situation.

(4) The ability to consider and evaluate unusual mathematical ideas to think through their consequences for a mathematical situation.

(5) The ability to sense what is missing from a given mathematical situation and to ask questions that will enable one to fill in the missing mathematical information.

(6) The ability to split general mathematical problems into specific sub-problems."

Statements made by NCFSE (2000) can yield some idea about measurement of mathematical creativity, "one of the basic aims of teaching mathematical in schools is to inculcate the skill of quantification of experiences around the learners. Towards this, carrying out experiments with numbers and forms of geometry, training hypotheses and verifying these with further observations from inherent part of mathematics learning. It would also include generalizing these findings with proof and developing competence to solve problems."

Theory, Nature and Characteristics of Creativity

Psychologists have worked extensively to know the causes of creative behaviour and in the process they have interpreted it in terms of literary attempts to scientific discoveries. There are theories of creativity and some of them are as follows :

(a) **Creativity As Divine Inspiration** : According to this theory creativity is a divine power given to some one by the Almighty. Plato believes that creative writer has no control on him rather his creative act is being controlled by some agent of higher power. Artists, poets, singers experience that they are being supported by some divine power to perform well, though such view has not received momentum in Science and Mathematics. Research on life style of scientistics and mathematicians of fame along with their feeling they received during creation may reveal something in this connection. Creativity according to this theory is innate and gifted.

(b) **Creativity As Madness** : Psychologists like Freud maintained that an artist was one who found in art a means of expressing inner conflict that would otherwise issue in Neurosis. Other groups of psychologists consider this view of creativity as negative and pronounces that creativity may take place without conflicts and translations. The theory is true to the extent that the creative persons creates due to their madness to work or think

continuously for long. Madness can be defined in different manner than Freud, but Freud's psychoanalysis suggests that creativity originates in a conflict with the unconscious mind.

(c) **Creativity As Intuitive Genius** : This theory considers creativity as a highly developed form of intuition. The creative person a rare specie, intuits directly and immediately. The theory considers creativity natural and supports the idea of the genius. Some persons may be extra-ordinary to fall in the genius category but latest researches have proved that creativity can be developed and fostered. Hindustan Times (2012) has considered Einsten as genius through a letter of PTI and has considered his brain (prefrontal cortex) responsible for it.

(d) **Creativity As A Cosmic Life Force** : The theory has its root in Darwin's theory of Evolution which puts emphasis on the fact that human creativity is the manifestation of creative force inherent in life and in organic matter. The process of Evolution Continually brings forth new species, unique,

unprecedented, unreatable, irreversible. Human creativity has also been seen as the expression of a universal creativity. Environment has is bearing on creativity and so it is difficult to accept this theory in absolute term.

(e) **Creativity As Association** : The theory considers thinking as the association of ideas governed by the laws of frequency, recency and vividness. Process of trial and error replaces older ideas from newer ones. The theory suggests more association, more ideas and more creativity. Other group of psychologists criticises the view by saying that the new idea does not emerge from past connections rather by breaking the past connections.

(f) **Gestalt Theory And Creativity** : This theory focuses on learning experience and perception as the basis of any creative act. The theory also considers problematic situation as essential for the birth of creativity. New theory of learning, i.e. constructivism, close to the Gestalt theory, do not consider learning experience and perception essential

for creativity rather theory believe in constructing creativity.

(g) **Other Theory** : Besides the above mentioned theories some other theories as theory of self-motivation, Theory of prestige and theory of will power, etc. are also talked. They consider creativity as the bi-product of self-motivation, Desire to gain prestige in society and will power to create.

It is difficult to favour or believe any one theory of creativity, but the things reflect some nature and characteristics of creativity. Researches in the area of creativity also suggest some nature and characteristics of creativity. Wilson, Guilford and Christensen have observed that creative process is any process which produces something new – an object or an idea including a new form or arrangement of old elements. The new creation must contribute to the solution of some problem. Torrance thinks that the process of creativity is similar to the steps in scientific method and a creative person uses the steps more often and more efficiently. The central element is the production of something new. Walllas (1926) has advanced a four stage analysis through which

a creator goes – Preparation, Incubation, Illumination and verification. The period of preparation is characterised by defining the problem, gathering data and material, choosing a plan of action etc. During incubation period unconscious mind of creator takes over and continues working on the problem in different ways. Illumination period provides some insight to reach on a thought or way. The necessary solution is suddenly realised during this period. During the period of verification the illumination is tried out and tested to determine whether or not it really solves the problem.

From the above discussions made under different heads we can write some significant nature and characteristics of creativity as :

- Creativity is the ability to develop something original.
- Creativity is the ability to create new ideas, theories or objects.
- Creativity has several dimensions.
- Creativity is a process as well as a product. An Environment and person is also creative.
- Creativity is the ability to synthesise ideas or objects.

- Creativity is the resultant of some interaction.
- Creativity knows no special medium, place, person or time.
- Creativity is the capacity to accept challenge.
- Creativity is the readiness to change self and environment.
- Creativity is the freedom to exercise choice.

The nature and characteristics of creativity reveals clearly that every person has some kind of creative talent and through training the creative acts may be redirected in the desired direction. Mathematical creativity is a specific type of creativity, limited to the field of mathematics but it to has many dimensions as described above through measurement of creativity (Mehdi) and mathematical creativity (Singh). As creative abilities may be increased through training it is one of the legitimate function of the education system to provide such training to foster creativity. Certain type of training to foster creativity need to given to the parents, teachers and other related persons so that they could make the product, process and Environment Creative. Kapur, J N (1995) has also emphasised to make mathematics teaching

entertaining and this can certaintly lead to creative presentation for better understanding of mathematics, “we can design a large number of mathematical entertainment programmes and organise mathematical entertainment similar to musical entertainments or films or photographic exhibitions or art exhibitions, but here the persons entertained have also to be motivated to participate intellectually and we have to design these programmes so that they get the thrill and entertainment with the least effort. Special efforts have to be made to use the visual and audio-visual media to make these entertainment programmes feasible.”

Fostering Mathematical Creativity

Development of a Nation or a Society largely depends on its creative manpower. Economist Amartya Sen has rightly choosen the education as major tool of talent development and has correctly correlated the development of the nation to the nurturance of human talents. Out of all the talents creative talent is most important and if it is related to a subject like mathematics; which has Utilitarian, Intellectual, Disciplinary, Cultural, Aesthetic, Vocational and many

other important values, its utility becomes more focused and specific. Mathematical Creativity and Teaching & Learning of Mathematics creatively are two important aspects which need attention of the educational world in general and mathematics education in particular. Sadly speaking, despite various recommendations, suggestions, experimentations and emphasis our mathematics teacher, process of Mathematics teaching and learning of the mathematics have not been able to respond on a creative manner.

Enriching our schools with mathematical creativity Teachers, Teaching – Learning process, Learning Environment and students are the major concerns. Rhodes (1961) and Kneller (1965) have identified creativity under four heads – Person, Process, Product and Environment Teachers of Mathematics must know and internalise the creative ways of Teaching and for the same they must get training in Intellectual skills, Teaching skills and Evaluation skills, along with continuous Inservice Training. Students must learn how to study and operate mathematical problems & events creatively. Identification and Nurturing of

mathematical creativity of the learners are essential acts for learning of mathematics creatively. Well equipped Mathematics room/laboratory, free and flawless discussion on mathematical issues/problems, optimum facilities and time to deal peculiar and new mathematical problems/situations can yield Creative Process and Creative Environment. Singh, R.J. (1988) has rightly expressed, "we must create a proper physical and psychological climate in our homes, schools and society at large so as to enable the creative impulses of our children to grow and develop to the fullest extent possible." Let us collect some specific ways to foster mathematical creativity to develop this man made world, i.e., of mathematics.

* Training the mathematics teacher in different types of skills (Intellectual, Teaching, Evaluation etc.) to present the content creatively. The skill of problem solving may be helpful for creative empression as identified by NCF (2005) "Many general tactics of problem solving can be taught progressively during the different stages of school : abstraction, quantification, analogy, case analysis, reduction to

simpler situations, even guess-and-verify exercises, are useful in many problem solving contexts."

* Utilisation of different methods of teaching such as Brain Storming, Group Discussion, Buzz Session, Seminar, Symposium, Interview, Panel discussion, Debate, Cooperative Learning besides the traditional methods specially Laboratory, Inductive – Deductive, Analytic – Synthetic, Lecture Demonstration, etc. Gulati, S (1988) has correctly suggested some ways to develop creativity in school students, "The major thrust is on group discussions, participatory activities, practicum, assignments and field visits for observation of creative activities." Kumar, Lalit (2004) also suggests the mathematics teachers to become a better teacher by making teaching child-centric and activity based. For better learning and achievement in mathematics Mehra & Thakur (2008) have suggested cooperative learning.

* Use of unconscious, Internal, Criterion – Referenced and Continuous & Comprehensive evaluation techniques for practice and analysis of different mathematical problems. Kumar Lalit (2008) has

suggested to utilise unconscious and oral evaluation and has also focused on the utility of training the mathematics teacher in techniques of evaluation. Agrawal, M (2007) has put emphasis on constructivist evaluation which is very much essential for evaluation in mathematics specially as creative evaluation technique.

* Identification of mathematically creative students and forming the teaching group for their development of creative talents in mathematics. Kumar, Lalit (2001) suggests to provide students the opportunities for creative empression to facilitate students learning in mathematics.
* Training the guardians/parents of mathematically creative students in the way they could help them to foster their mathematical creative talents informally and at times non-formaly.
* Researching in mathematical creativity specially with respect to the relationship of creativity and other psychological traits. Kumar (1994) concludes, “Altitude towards mathematics plays a significant

role in the development of mathematics." There are other similar findings.

* Inriching the students through effective communication process, proper infrastructure, well equipped library and laboratory, organization of mathematics related co-curricular activities, creative discussions, genuine experimentation etc.
* Developing creative style of self study among the mathematics learners. Hindustan Times (2012) through a letter of PTI has mentioned the findings of a research done in Oxford University that Boredom can encourage creativity in kids.
* Identification and Measurement of mathematical creativity as early as possible.
* Review of Teacher Education programme for the development of some mechanism for developing mathematical creativity.
* Arrangement of some special programmes for development of mathematical creativity.
* Formation of committee for the identification and development of creative talents at National, State, District, Block and Panchayat Level.

* Development of some Instructional Materials for committee members, teachers and parents.
* Creation of creative environment in schools for creative expression and its development.
* Introducing the topic of Mathematical creativity in the curriculum at secondary and Teachers Training Level.
* Special provisions and arrangements for counseling of mathematically creative talents.

Nepolean has rightly expressed that the development of the society is related to the development of mathematics in the society concerned and so for the development of the society and the nation as well there is the need to have and produce creative mathematics teachers, creative mathematics learners, creative mathematics teaching-learning process and creative environment. The world of mathematics education need to care the mathematical creativity to have a beautiful, peaceful and creative world as desired by Delor's through its report – learning to be and learning to live together.

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Dr. Lalit Kumar
C-1/5, Professors Colony
Saidpur Complex of PU
Behind Rajendra Nagar Stadium
Patna-800016