Analysis of Well-Conducted Models of Creative-Problem Oriented Teaching and Learning of Mathematics

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Abstract: Mathematics expresses quantitative relations and spatial forms in carefully, purposefully, and often ingeniously designed compact symbolic language and express what in ordinary language would be unwieldy or ambiguous. Its language is precise, so precise that it is often confusing to people unaccustomed to its forms. NCF (2000) recommended that the study of Mathematics contributes in the development of precision, rational and analytical thinking, a positive attitude and aesthetic sense among students. , Mathematics has no content of the type that one finds in History, Geography and Science. It consists of certain structures which can be imposed upon or drawn out of any life situation which permeates into the other subject fields too. It can be read in Dance, Music and Physical Education. The main objective of the study is 'To study cases of well-conducted models of creativity / problem oriented teaching, taking special care to note if and how the basics are built in or extracted'. For this purpose the investigator analyzed well conducted models of creativity/problem oriented teaching mathematics and other subject knowledge can be drawn out of certain activities. The investigator tried to study the pedagogical aspects of such models. The analysis of the well conducted models of creativity triggering / problem solving approach enriched the pedagogical aspects of the basic mathematics component in various dimensions. The integrated models of musico- mathematics enhanced the investigator's theoretical knowledge of musicology. This could lead the present investigation to identify multiple contexts for promoting creativity and problem solving approaches in mathematics along with the basics.

(Key Words: Analysis, Well-Conducted Models, Creative-Problem, Teaching and Learning, Mathematics)

INTRODUCTION

The pattern and form of events and things are taking shape in his mind, as his ability to use representative objects shows. In each activity of the child, an awareness of a mathematical relationship is shown in the particular representation, but it is clearly without precision. There are three types of experiences from which a child's awareness of mathematical properties come: (1) repetition of experiences of the same object or event (2) the contrast between two different things or events (3) his own manipulation of things or his observation of their behaviour.

Williams and Shuard plead for ample opportunities for the child for (1) experimenting and constructing with a wide range of objects and materials, (2) making their own judgements, (3) expressing their findings in their own ways, and (4) thinking through for themselves the way to new discoveries and the solution to problems.

Graham and Nicholas have analyzed practical mathematics from two points of view: The first is linked to practical apparatus like Dienes blocks and Cuisenaire rods and the second is to think of practicals in the sense of real world problems and everyday situations. The structured apparatus properly handled helps children to literally feel concepts such as shapes, position and measurement. But often they are used in a traditional way, apparently with the belief that if children manipulate the pieces in the prescribed way, they will absorb the underlying mathematical ideas by osmosis. But if a clear goal or purpose for the activity is not explicitly shared by teacher and pupils alike, these apparatus may not yield the best results.

LITERATURE REVIEW

The spirit of Mathematics with its elements of Problem-solving, discovery and insights fits much more closely with Gestalt psychology developed by the German psychologists Kohler, Koffka and Wertheimer. Wertheimer later migrated to the United States and his *productive thinking* is profusely illustrated with examples from mathematics. The important contribution in his analysis is the focus on the structuration or envisioning comes most naturally with geometry but extends to other fields of Mathematics as well.

Wertheimer (1959), while analyzing the example of solving problem of the area of the rectangle clarifies that the thinking processes involve a number of operations. There is grouping, reorganization, structuration, operations of dividing into sub wholes together, with clear reference to the whole figure as in view of the specific problem at use. Wertheimer calls the teaching- learning processes adopted by him as genuine, fine, clear, direct, productive processes, in contrast to the traditional approaches. These processes are essential to thinking. The very nature of these operations adequate to the structure of the situation is alien to the gist of the traditional approaches and to the operations which they consider.

Gagne (1984) is a leading psychologist in education who recommends a behavioristic approach in teaching. Gagne's eight sequential steps of hierarchical learning for pupils may be of considerable help for teachers in planning the mathematics curriculum. The eight steps of sequential learning are: signal learning Stimulus response learning, chaining, verbal association, multiple discrimination, concept learning, rule learning and problem solving. Gagne used the idea that a sequence of tasks could be established for a desired learning outcome. If the student practiced each required task as it was learned and developed, that student would then be able to move on to the next step in the continuum. Gagne has been largely concerned with an attempt to clarify the relationship between the psychology of learning and instruction, that is, of arranging the conditions to bring about the most effective learning of intellectual skills, cognitive strategies, verbal information, motor skills and attitudes. These five areas are defined by Gagne as 'categories of capabilities'.

NCTM'S Agenda for Action (1980) also calls for problem solving skills beyond computational facility, full use of calculators and computers, more required Mathematics study for all students, and a more flexible curriculum to meet diverse student needs.

The vast body of revolutionary developments in mathematics education looks place in the western world, triggered by the sputnik stimulus in the late 50's and in the early 60's. Programmes like SMSG and Illinois Mathematics (USA), SMP, and Nuffield Mathematics (UK) were among the most popular. Since the Soviet Union presented a high level of abstraction in the school mathematics textbooks and since axiomatic play an important role in modern mathematics some schools tend to approach mathematics "from above", a stance justified by Ausubel's Advance Organizer Theory.

OBJECTIVE

The main objective of the study is 'To study cases of well-conducted models of creativity / problem oriented teaching, taking special care to note if and how the basics are built in or extracted'.

METHODOLOGY

For this purpose the investigator analyzed well conducted models of creativity/problem oriented teaching mathematics and other subject knowledge can be drawn out of certain activities. The investigator tried to study the pedagogical aspects of such models.

Environmental Models for mathematics by Mercykutty (1996)

Mercykutty (1996) in her study on Models of Teaching Mathematics Using Environmental Resources made a series of explorations such as observing several patterns in the environment, learning or observing several crafts and simultaneously extracting the mathematics embedded in them, a group project on extracting mathematics embedded in Onam celebrations (attappu patterns, seeing the plantain leaf as parabola and so on). The models were grouped finally as: Free exploration, Patterning, Ecstasy through mathematics-music convergences, Ethno mathematical models, Linguistic-related models, Inter-disciplinary models, Grid analysis, Bridge models, Artistic vision, Gestalt vision, Socio-cultural learning climate, Project model and Physically perceived space penetrated through mathematic-philosophical space. The last one is very deep. On all the rest 'applications can be found from Class 1 to 10.

Musical models in animating the school education by Manuel &Philip (2000)

Philip (2000) developed and tested Musical Models in Animating School Education. His first two hypotheses relates to the dull drab routine of the ordinary school climate and the low place given to music in the schools of Kerala. The third hypothesis cluster specifically relates to the state of DPEP as it was when he started the study in 1997: The DPEP has introduced a lot of singing and activity at the lower primary education; but the animation is by and large on the external side; the inner animation characterizing modern music education in progressive systems is yet to take off; this animation is at the expense of the basics of education (in 1997); the dialectic implied in Dewey's The Child and the Subject is yet to be recognized and resolved. Much of Philip's analysis is at a deep level such as music linguistic coding, musicological analysis (Western and Indian). But his models on "Musical rhythm: Poetic Meter: Mathematics convergences" take off from Elementary arithmetic in Children's Rhythm (clearly bringing out Bruner's enactive-iconic-symbolic sequence.

Table 1

Musical Rhythm, Poetic Meter, Mathematics Convergences in the Musical models in animating the school education

Poem Verbal rhythm: Secant (iconic)	Onnanam Ta kit a ● ● ●	Kunnile Ta ki a ● ● ●	Oradi Ta ki ta ● ● ●	Mannile Ta ki ta ● ● ●
Poem Verbal Rhythm Secant (iconic)	Orayi Ta ki ta ● ● ●	Ramkilli Ta ki ta ● ● ●	Kuduvach Ta ki ta ● ● ●	Chu Tom ● ● ●
Number count	1 2 3	1 2 3	1 2 3	123

When children are simply singing the song and clapping, stamping their foot, tapping, dancing etc., they are doing so with a rhythm of 1 2 3. This is enactive mathematics (i.e., with their muscles etc they are doing mathematics). That mathematics cannot be shown in print, though children will feel it. It is just shown in the vattari count ta ki ta. But then enactive mathematics is fleeting. So the iconic form with secant patterns fixes it for inspection and analysis. With the iconic bridge children can see them and group into threes, count as 12, do multiplication 4 x 3 = 12, divide a line of 12 beats into four threes. (Such mathematical work was done by Kodaly in Hungary and Orff in Germany-USA.) This is one of the easiest things to do. It is possible to make even more complicated rhythm mathematics. Children can easily do it at the clapping level. If the same mathematics is given directly in symbols they will be afraid. With the iconic bridge, which they can slowly inspect, the transition from the joyful enactive mathematics to the symbolic notebook mathematics becomes easy.

The following enchanting rhythm given in Poothiri 1, can be recalled and used for teaching fractions and more difficult mathematics in class 4: The rhythm goes in fours. Since it is recited fast, it would be appropriate to count two beats to a bar (musical ganam). In some cases the second beat is divided into two half beats which fill one beat as shown below. The sense of fraction is felt in the blood. It is the pre disposer for learning formal fractions later.

Table 2

Verbal Rhythm, Number Count , Mathematics Convergences in the Musical models in animating the school education

Poem Verbal rhythm: Secant (iconic)	Tappit- Tom ki ta ● ● ●	Tappina Tom ki ta ● ● ●	dakkunna- Tom ki ta ● ● ●	Tendinu Tom ki ta ● ● ●
Number Count	One two	One two and	One two and	One two and
Poem	Takkida	muttass-	I	

Verbal Rhythm Secant (iconic)	Tom ki ta ● ● ●	Tom tom ● ●	Tom…. ● ●	● ●
Number count	One two	One two	One two	Three four

In reading the small font two and should be recited fast so that it will be recited in the same time that a normal font 'one' or 'two' will take (This way of counting becomes a fraction vattari representing ki (a equivalent to one Tom). When written in this form this may seem cumbersome. When actually working with children clapping and pasting secants and half secants the whole thing will be enjoyable and clarify fractions. Here again sometimes the children may not immediately get the point if they are thinking another mathematics. The teacher may represent half secant as fraction. The pupil may be counting 'two and' as two wholes. Repeated play of enactive mathematics and putting the two halves, as 'one' will suddenly develop insights that will be permanent.

It will seem more close to the point to take one or two concepts in mathematics not very effectively brought out from the illustrations given in the text. It was mentioned already that the textbook number ladder goes only up to nine: 1 2 3 4 5 6 7 8 9 and comes down 987654321. Teachers supplement it by adding in their charts one more step and write 10. Some write it on the tenth step. Some write on the top of the plank. In the investigator's view the latter is better - to indicate that one ladder of ten steps" is completed. If this point is disputed there is no point in experts arguing about it. Both forms are to be tried out with pupils and whichever works with them is the best - at least for them. Some teachers and trainers take the number ladder up to 20. Most of them make a long ladder with 20 steps. This will not clarify the ten base grouping. It is better to complete one ladder with 10 and put another ladder of ten above it. Now if the children count up and write the numbers, writing 11, 12 13 etc, these double digit numbers will match with one completed ladder plus one, two or three steps etc. Such a model of numerals 1 to 20 with two ladders each often steps is shown in Figure 1.

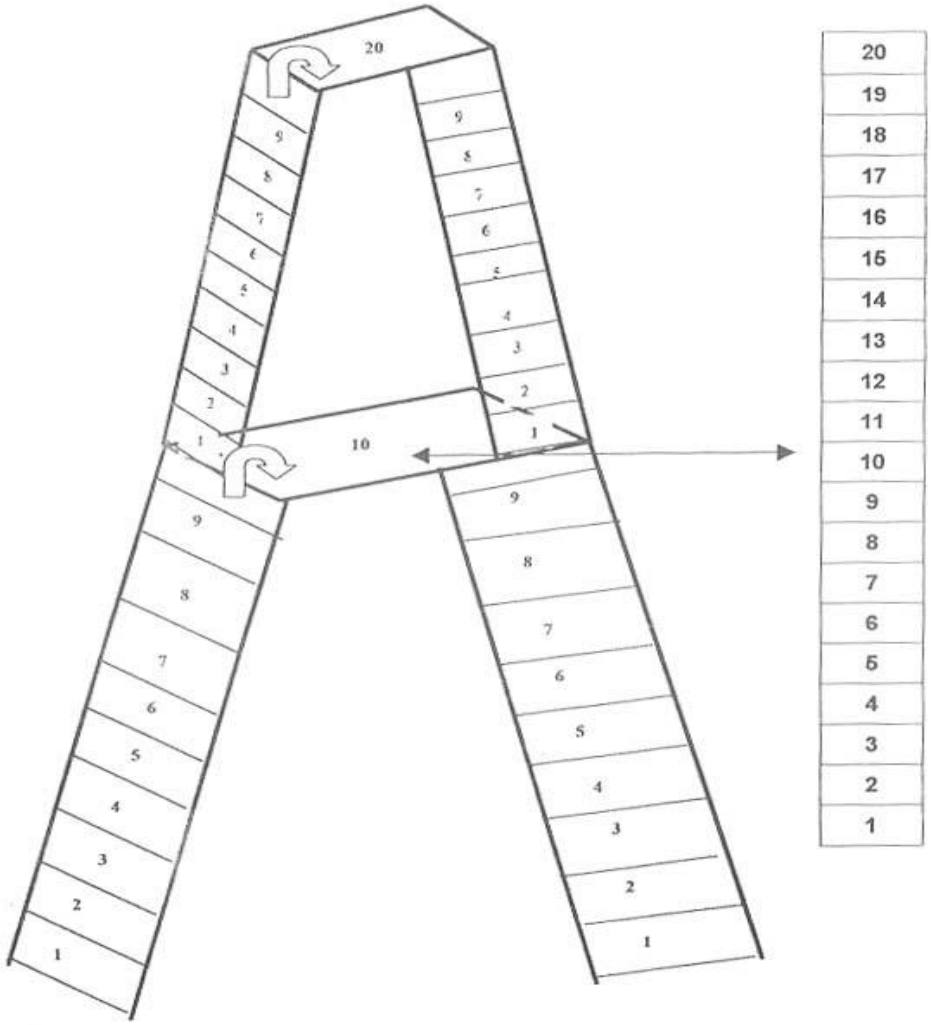


Figure 1: Integrative Models for Arithmetic by Manuel 2001

But even this is only iconic (visual). If children actually climb in ladders or in two-phase stairs, with a pause at 10, it will be still better. It is also possible to make improvised 'ladders' (in which one cannot climb - but which can be handled) with plastic chairs placed one upon another. As soon as ten chairs are completed, they are tied as one unit and the eleventh, twelfth ...nineteenth (If Malayalam is literally translated, they can called 'ten-oneth', 'ten twoth' — 'ten ninth' (11, 12 ... 19). (This was actually tried out with success in a Multigrade Learning Centre in Nilambur forest.

This artificial language if carried into the English of mathematics will make the concept and representation match even better. The superiority of the Malayalam thinking for digit conceptualization over English - and still better form over Hindi (at this digit schema formation) will now be clear. Many poor children who have been pushed into English medium at this stage get more confused and some of them remain as mental dropouts for some years, and later come back to government schools with TCs. The richer children also have the problem, but parents or private tuition masters work with them and clarify the point

slowly. Once a child survives in English medium mathematics up to twenty, his chance of survival is very high because English becomes number-friendly from 20 to 100. It presents difficulty only at the crucial point of learning the second digit for the first time. This is a problem faced by English children in England too. Some innovating English teachers improvise Malayalam type 'ten-one, ten-two' also along with eleven, twelve. This helps the children to grasp the two-digit 11, 12 etc better.

It was pointed out that after marking time too long with small number, there is a quick progress to additions yielding two-digit sums: 8 + 7, 5 + 7 etc. The exercise form is made attractive through connection with strings, spider legs etc., but the mathematics concept and schema formation is bypassed. It seems to be assumed that through rote memory and mental mathematics recall, the problem can be solved. In ordinary life this is how it is learnt, but to really understand what happens in the mind when 'two large numbers' are added and split as 'two small numbers' lay out in two digits 5 + 7 = 12 takes time. If the pupil has understood the addition schema at this point he can generate the answer even for problems for which he has not got an addition table in his memory. A model illustrating how to help the child construct the schema for addition spilling into the second digit using concrete support is given below. Figure 5.2 presents a device of a metal wire bent twice as shown, holding exactly ten beads. The addition 5+7=12 is explained in four steps.

1.

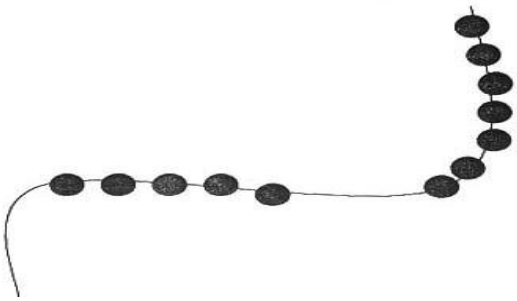
In step 1, the wire space is filled with exactly ten beads. It has become one 'wireful', indicated by the 'I' promoted to a higher 'tens' digit.

2.

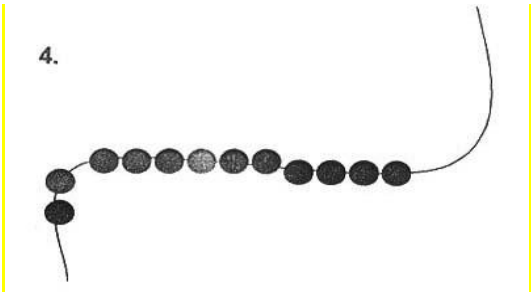
Now if we want to do the sum 5 + 7 =?. We first put five beads in the wire. The five beads can be seen on the string (Step 2)

exactly ten beads. K has become one 'wireful', indicated by the 'I' promoted to a higher 'tens' digit. There are no more bends. So we put '0' in the 'ones' digit

3.



Seven has to be added. Feed seven beads in the upper loop of the wire. This is shown in step 3. The 'addition' is done by gravity. The seven beads come down.



The first five coming down completely fill the wire and make one full 'ten'. There is no more space in the wire. So when the remaining two come down, two from the 'original five' are pushed down and are falling as individuals' or 'ones'. Now the child sees one 'wireful' - '1' written in the higher digit level. The two dropping-out beads are the 2 ones. Thus 5 + 7 = 12 (Step 4 in the

Figure: 2 Addition of 5+7

Many structured apparatus have been used all over the developed world for more than seven decades. They have somehow been neglected in our system. In DPEP some creative teachers do make their own structured materials with matchstick, matchboxes-etc. If such teachers are confronted with the materials of Dienes, Cuisenaire, or even Montessori - the last was used in many schools in India earlier - they can do even better.

If the mathematical structuring sense is developed through understanding of structured apparatus and the principles underlying them (e.g., Stern's apparatus was based on Gestalt principles, Montessori apparatus on simple arithmetic, Cuisenaire rods covering a large number of areas, Dienes apparatus taking off from the simplest to even multibase mathematics. The important thing in all these apparatus is that the abstract concepts that many teachers try to convey through verbal repetition, and consider those who don't understand them as dull or even uneducable, can be conveyed in structured play.

Actually the play offers the chance to do representational or concrete operational tasks. The mental constructs will occur suddenly to the child. Till then what was torture for many children in the traditional system is a pleasant experience in integrated approach. The apparatus provides concrete activity, disposing towards the constructs, which the child himself will make in due time, but much faster than with purely verbal approaches. In progressive systems many retarded children who did not respond to verbal methods are reported to have made remarkable progress.

DISCUSSION

The analysis of the cases of well-conducted models of creativity/ problem –oriented teaching showed how the basics are built in or can be extracted through various approaches. Mercykutty's(1996) study on **"Developing and Testing Models of Teaching Mathematics Using Environmental Resources"**

seemed to go away from directly drilling the basics and employed problem-solving, creativity nurturing models, besides other approaches. But it was shown that basics were strengthened by this indirect approach. In this study the traditional and the progressivist approaches to the teaching of mathematics was set in dialectic. Manuel's (2001) study on "**Integrative Approaches in Classroom Transactions of Poothiri Texts, Sub-texts, Inter-texts and Contexts"** which has brought out clearly the debate between formal teaching of mathematics and drawing it out from various environmental contexts, through dialectic.

CONCLUSION

The analysis of the well conducted models of creativity triggering / problem solving approach enriched the pedagogical aspects of the basic mathematics component in various dimensions. The integrated models of musico- mathematics enhanced the investigator's theoretical knowledge of musicology. This could lead the present investigation to identify multiple contexts for promoting creativity and problem solving approaches in mathematics along with the basics.

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