SIGNIFICANT AND COGNITIVE LEARNING OF MATHEMATICS

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A discussion is going on about teaching of mathematics at school level. As many students fail in mathematics some people are against making it a compulsory subject. It is evident from this fact that mathematics learning is not treated as a means of personality development. For various reasons most of the pupils remain outside the learning process. The investigator felt the need of helping student teachers to become aware of Carl Rogers' views about learning though it is not included in the B. Ed. syllabus. But student teachers are expected to learn the concept "a facilitator" and it is senseless to talk about facilitating learning without Carl Rogers' theory.

Carl Rogers distinguishes two types of learning: cognitive (meaningless) and experiential (significant). Rogers lists following qualities of experiential learning: personal involvement, self-initiative, evaluation by learner, and pervasive effects on learner. Keeping in mind this view I tried to develop a learning programme for student teachers. In this programme a group of twenty two student teachers were assisted to learn and design mathematical activities for cognitive yet significant learning. All learning activities were conducted in the form of workshops. Emphasis was on achieving objectives and not on completing the topic. This involved learning of most of the concepts like angle, circle, triangle, rectangle, area, volume and volume of sphere, parallelpipe, cylinder etc. During the workshops student teachers were encouraged to discuss pedagogical aspects of teaching, learning and evaluation process.

ORGANIZATION OF LEARNING EXPERIENCES FOR STUDENT TEACHERS

Stages involved in significant learning are as follows:

Planning for experience

Increasing awareness of the experience

Reviewing and reflecting upon the experience

Providing substitute experience

Stage of reflection offers learner to make use of metacognitive skills. These skills play important role in learning to learn, learning to do, learning from each other and learning to be. To Rogers, experiential learning is equivalent to personal development which includes change and growth. For Rogers all human beings have a natural tendency to learn and the teachers' role is to facilitate that learning.

Facilitating learning includes:

Setting a positive climate for learning

Assisting learners to clarify the purpose of learning

Organizing and making available learning resources

Balancing intellectual and emotional components of learning

Sharing feeling and thoughts with learners but not dominating

Most of the pupils do not like to learn mathematics as they are forced to accept representations developed by others. Students who have their own ways of tackling this problem, succeed in the examination. But for a larger section of pupils it is a meaningless burden. Similarly student teachers opt to teach mathematics not because of their mastery over the subject or love for the subject. They want to become mathematics teachers as omparatively more job opportunities are available. Thus it is necessary to make room for considering emotional aspect of mathematics during learning. Student teachers rarely get a chance to experience 'experiential learning' during their school education. To give them the needed experience it is necessary to organize learning experiences that give them an opportunity to experience learning and teaching holistically.

A major constraint in using experiential method is the attitude of concerned persons. For most people, the learning process is a waste of time. According to them pupils should be engaged in learning things (or helped to remember the information) that are important for examination. In this situation engaging learners- student teachers and pupils- in a learning process takes a longer time. When student teachers go for practice teaching, school teachers not only discourage but insult them when they try to evolve a process oriented learning situation. They force student teachers to complete the exercises given in the textbook. Efforts were made to help student teachers enter into learning wholeheartedly. At the same time care was taken not to lose importance of structure and rigor of the subject. Similarly I tried to play a role of responsible facilitator and intervened only when it was very essential. I suggested some activities to speed up the learning process.

Described below is one set of activities that evolved during one such workshop. In this case student teachers were asked to design activities for organising learning of the concept 'volume of a cone' before experiencing 'experiential learning of volume of a cone'. This was done on purpose as many times student teachers complain that 'pupils know everything and there is no scope for teaching'. I wanted to put myself in the same situation where 'students know everything'. I asked students to involve in learning as ten plus learners and they are pupils who have attended 'vacation classes'.

Stage one:

At this stage students were assisted to justify need for learning to calculate volume of a cone. It became clear to the group that in our surroundings, a negligible number of things have a conical shape. They were suggested to describe the shapes of hills, and Christmas tree. Some students felt that conical shape is easy to hold by hand and offers more space. Tapering end of the cone allows one to have good grip and enjoy ice cream comfortably. They were asked to guess the use of the conical flask in the laboratory, conical container used for measuring kerosene. This discussion reminded them of the joker's cap and it was decided to make a cap using paper economically.

Students struggled hard to get an angular shape without wasting any paper. They made a cap using a rectangular piece of paper but getting a piece of exact shape was a problem. Some students were trying to make a cap using equilateral and scalene triangle. They were suggested to draw pictures of a cone from different perspectives, observe them carefully and compare it with a triangular

paper. Some students preferred to compare pressed cone and triangle. Following observations were noted:

In case of regular cone distance between any point the circular edge and the vertex is equal.

In case of triangles distance between any vertex and any point on the opposite side is not equal.

At this stage students were asked to describe or define the shape that they were observing. They tried but did not come up with satisfactory statement. But this led some students to work with circular paper pieces. Now they started struggling with the problem of converting two dimensional papers into three dimensional cones. They were suggested to make use of tailor's skills, Diwali lantern making skills for using circular paper for making a joker's cap. After taking a lot of time one student made a single incision along the radius. One student decribed this as 'taking out center of circular piece in a different plane.' This motivated other students to experiment with radial triangular cuts and caps were ready. At this stage again they were suggested to define a 'cone'. There was a discussion on this and students came up with many statements like 'a set of congruent segments emerging from a single point and their other ends points form a circle in a different plane'. Students were suggested to list out possible variables that can be measured and design an experiment to find out relation between different variables. Two experiments were planned.

Circles with identical radii and their pieces having different angles were used to make caps.

Circles with different radii and their pieces with identical angles are used to make caps.

These activities were spread over two consecutive periods of fifty minutes each.

Teacher: Why did you think that equilateral or scalene triangles are useful for making a cap?

Student: Shape of joker's cap appears to be triangular.

Teacher: It appears to be or is it a triangular shape? Observe shape of the cap.

Student: There is a triangle.

Teacher: This means that you made a wise observation. Now find out how this triangle is embedded in this shape.

Student: When we make this cone flat one side is a curve. There is no triangle.

Teacher: We have studied a circle. Let us see how that learning helps us in this case. Now observe this globe. Can we define this sphere in terms of circles?

Student: It is composed of many circles.

Teacher: Can you make this definition more precise.

Student: It is made up of infinite number of circles of varied radii.

Student: It is composed of infinite circles of varied radii. The circle at the equatorial region has the longest radius and as we move toward both the poles radius of circle gets on decreasing in length. At the poles it is just a point. (Writes on board.)

Teacher: Can we say that both the poles of sphere are 'point circles'? Radius of this circle is a point. Isn't it?

Student: We will have to confirm this.

Teacher: Now read the description carefully. Can you use it to describe a cone?

Student: We have to make some changes. It will be like this. The base circle has longest radius and as we move toward vertex radii of circle get reduced. A vertex in this case is a point circle.

Teacher: Can we make it more precise?

Student: ...

Teacher: What can we say about position of these circles?

Student: They are placed in such way that the line joining their centers is perpendicular to every circle.

Teacher: It is true that in case of sphere and cone, length radii of circles get reduced toward poles and vertex respectively. But are rules of reduction are same? Isn't it necessary to clarify? Did you notice this?.. Thus our definitions are not perfect.. Is there any other way to define a sphere... Can we define it in terms of congruent circles?

Student: Yes. It is composed of infinite numbers of congruent circles.

Teacher: Is it not necessary to make it more precise?

Student: It is made up of infinite circles having a common diameter or common symmetrical axis.

Student: I don't understand this.

Teacher: Please try to explain her using concrete material.

Student: (points out longitudes)

Teacher: Is there any other way to explain this?

Student: ....

Teacher: (I am tying this circular bangle to this pencil with rubber bands. Section of this stick serves as a diameter of a circle. If I churn this stick what shape will you be able to see?

Student: Will it be a sphere? Let me try... Yes it is a sphere.

Teacher: We could see sphere due to the phenomena of persistence of image. Can we use this experience to define the sphere? (Students give definitions.) Now look at the triangle and a cone and try to understand their relationship.

Student: Now I got it. If I paste this triangle to this stick and churn the stick we will get a cone.

Teacher: Is it your hypothesis or is it a fact?

Student: We can experiment with it. (All student teachers do the activity.) Yes. Our hypothesis is accepted.

Teacher: Why did you fail to see this relationship just by looking at the paper model of a cone?

Student: We fail to see that the base of a cone is a circular region made up of base segment of the triangles. I was confused by the shape of a flat cone.

Student: Now we can describe the cone as composed of infinite number of scalene triangles having common axis of bilateral symmetry.

Third period was used for increasing awareness of this learning experience. Student teachers were requested to write about their learning experience. This is a difficult task as student do not participate openly in the discussion.

Stage two:

Student teachers pointed out the different aspects of learning. Some are listed below.

"Being engaged in the learning process throughout the period there is a feeling of freshness and satisfaction that I learned something that is new to me. We were engrossed in the activity. (One student did not agree with this. She did get bored.) For example I was thinking that two triangles are sufficient to make a cap but it had no space for the head. I enjoyed being realised that for getting a conical shape radial section of a circle is needed."

"The problem of making a cap economically helped us to get motivated sufficiently and remained motivated for a longer duration. Experimenting with different conical shapes helped me to understand relationships of different variables. In constructing a cone two circles are involved. One circle; rather circular area; involves in the formation of conical surface and other circular area forms the base of a cone. Formula that we use takes into consideration the circle that forms a base of the cone."

At this point students were suggested to find out reason for using circular base of a cone to find out the volume. In the beginning students came up with different ideas of finding out formula for volume. They were suggested to study and compare formulae of a cylinder and a cone. Students experimented with cylinder and cone with identical heights and bases. A group of students made paper models and using sawdust tested their hypothesis. Student also developed formula for surface area of the cone.

After this students were helped to review and reflect upon the experience.

Stage three:

For helping to review and reflect, students were suggested to make use of following questions. Did you know the formula before this experience? Did your understanding of learning mathematics and this particular formula changed due to this experience? Do you feel that this experience helped you to acquire any new skill or skills? Did you at any stage of learning feel that you are wasting your valuable time and energy? Is not this learning is wasting of time for learning a simple formula? Did not you learn some craft work and mathematics together?

Some of the reflections are given below. Student teachers' reflections are mixed with their teaching experiences.

"I feel that this is a waste of time. While practicing school lessons we are not allowed to execute this kind of learning activity as pupils make lot of noise like we were making while learning. I never experienced this kind of teaching myself in school days. This means something must be wrong with this method itself. Why to waste time and energy just for learning one formula? When students work out exercises repeatedly they become familiar with the formula. Putting a chart of all formulae in the class will help pupils to remember them in the long run. Though I did not know all these aspects of volume of a cone that I learned today they must be there in some book. You are not giving us the name of that methodology book otherwise we can read the book and plan a lesson accordingly."

"I knew this formula very well and I can use it for calculating volume of a cone if sufficient information is provided. But I was using it mechanically. During last month we had evolved a formula for calculating volume of a cylinder using this method. I wanted to use experimental method but I failed to 'see' its relation with the circular surface and cone... This made me use

triangles for making a joker's cap. Similarly I used my experience of making cylinder for making a cap. We did get circular base using edge of a rectangular paper while making a cylinder. Thus it appeared to me that a triangle can be used for making a cap."

"I did not think of learning this formula using experimental method. Although last time we tried to look at the object and then try to figure out the formula I did not able to do so in case of a cone. Our previous learning is working against our new learning. While working in a group we found that none among us was thinking differently. Our vision was tied up with the formula and it deterred us from thinking differently. My view about learning mathematics changed a lot but it did not affect my own learning process. I enjoyed being a learner but I do not have confidence in organizing this kind of learning experience. I will have to learn to have patience for organizing this type of learning environment. I think I will have to learn to understand the subject on my own. These things we don't find in the books."

"This type of learning experience gives me negative feelings. It appears to me that our school education is useless. We read in the method book that requiring a longer time duration is one of the demerit of an experimental method. When we say that learning is a process of personality development then emphasis should be on learning process and required time slot should be provided to learners. What I experienced during these activities that any one can learn mathematics. During school days I used to get feeling that teacher dragged us along with her solving exercises only. I do not remember learning mathematics in the school, instead we completed exercises. In our class we did not work out D level exercises. We are doing the same during school practice teaching."

Stage four:

At this stage student teachers were suggested to design experiential learning activity for developing concepts and formula for trigonometry. Student teachers' ability to apply 'knowledge' gained through this learning experience was at test. This was not their first experience. In spite they were not able to come up with the experiential learning design. This might be due to the lack of practice in using ones creative skills or lack demand for this kind of teaching in schools. Student teachers usually avoid using laboratory methods as they are not supported by school teachers or supervising teacher educators.

CONCLUSION:

It is possible to combine cognitive and significant learning by organizing open and problem based learning experiences. Though mathematical activities evolved are time consuming they invite learners to apply their thinking skills. This opportunity to think and experience its success in gaining "knowledge" might help learners to become familiar with their own potentials. Most of the learners feel that knowledge must be there in some book or with some clever or wise person. They fail to realise the fact that they can construct the knowledge and it is one of the important skill that is needed in this learning age.

Though I use this method to facilitate learning of mathematics teaching, I fail to convince its importance to the majority of student teachers, teacher educators and other concerned people. Students and teachers are against working for a longer time. Thus evolving a culture of 'experiential

learning' is out of question. Similarly student teachers fail to transfer this learning to teaching of other concepts. I feel that there is a need of organizing many cycles of learning for student teachers there though are many hurdles and difficulties.

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