

INVESTIGATORY APPROACHES IN MATHEMATICS TEACHING: IMPLICATIONS FOR TEACHER TRAINING IN INDIA

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In the present age of Science & Technology it is very much essential to develop the process skills, experimental skills, thinking skills and the skills of exploration among the school children. Mathematics is an appropriate subject to inculcate and develop these skills through Investigatory approach. So it is necessary to know to what extent Investigatory Approach is adapted while advocating it in teaching mathematics, in the Initial Teacher Training Institutes and its impact on teaching mathematics in the Secondary Schools. An attempt is made to study in detail how the Investigatory Approach is adapted in the Initial Teacher Training Institutions at the University level and how is it practised at the Secondary school level to improve the quality of mathematics education. My observations, findings and their implications to the Teacher Training in India are put before you for discussion. Any suggestions offered are highly appreciated.

1. Introduction

Recent Research findings in different parts of the world are stressing the need of adoption of strategies that provide opportunities for children to think rather than use the product of thoughts, to do mathematics instead of reading and listening mathematics. In India there is a great dissatisfaction among mathematics teachers and teacher educators about the way mathematics is being taught particularly at primary and secondary school level. We feel that we are not providing sufficient opportunities and environment for the pupils to think mathematically. In this context I came to England on 29 July 1997 to study the Instructional Strategies and Information Technology adopted and advocated in Initial Mathematics Teacher Education Courses in Teacher Education Institutions in UK and their impact on the quality of teaching and learning mathematics at Secondary school level and their relevance to the local conditions in India.

Of all the strategies that were used in the PGCE, the investigatory approach caught my attention since it is the approach that is based on Ausubel & Robinson's (1971) psychological aspects of mathematics learning namely 'Meaningful Discovery Learning.' When I came here there were so many questions on my mind and I was very keen to find the answers for them during my observation of the sessions. They are

1. What are the features of an investigatory lesson (including the role of the teacher)?
2. What factors facilitate trainees' use of investigatory approaches? (a)
presence of approach in placement school
(b) beliefs in philosophy in placement school
(c) beliefs in trainees
(d) university sessions embodying approach in incorporating discussion of lesson approach

(e) university sessions embodying investigatory approach

These questions worried me because the way that we follow this approach in India is not systematic or well structured. At the Primary School level we call it 'Activity Based Learning'(ABL), not an investigatory approach.

2. Current use of Investigatory approaches in Indian Primary & Secondary Schools In ABL, the teacher provides an open-ended activity to all the students in the class by setting up a task based on the set mathematics syllabus. At the end of the task the findings of the students are summarised. To mention few

1. Post-Office activity: It is a whole class activity. To teach about Indian currency and money transactions' children are allowed to take as much toy-currency as they want (initially a particular amount). With the amount picked up they plan to buy the stamps and envelopes. In a simulated situation they do the money transactions. Those who complete the buying they plan the other combinations possible with the same amount and make a list.

2. Kiddy Bank Operations:- It is based on actual money transactions. This activity starts at the primary school and continues till they leave school. High school students manage the bank operations (issuing the pass books, withdrawal forms, maintaining the cash book ...) and all the primary and secondary school students use the bank services.

3. School Stationery Shop:- It is run by the students. Goods are sold at concession rates and the Profits are used for the benefit of the students.

4. Activities using tamarind seeds: Students explore innumerable mathematical ideas using this activity. This is used at primary school level.

- a) Splitting the picked up seeds in different numbers of groups in different ways.
- b) Splitting up the picked up seeds to show the subtrahend, minuend and the remainder in different ways.
- c) Showing the picked up seeds as a product of two or more factors in as many ways as possible.
- d) Distributing the seeds picked up among different students of their choice equally and asking them to explain how many seeds were distributed, how many each got and how many are left.
- e) Ratios, fractions, percentages, patterns, arrangements and so on.

5. Planning school bus routes to teach route matrices (at Secondary school level).

6. Wiring a building - for teaching incidental matrices (at Secondary school level).

7. Activities leading to exploration of relations and generalisations - before teaching theoretical proofs in geometry (at Secondary School level). It is somewhat like guided discovery.

3. Current use of Investigatory approaches in Teacher training in India

The Investigatory approach is not directly adopted in teacher training. All institutions advocate it but few give direct experience of it to teacher trainees. It is insisted that during micro-teaching, every student

teacher has to teach at least one lesson using this 'activity based learning'. Feed back is given to each student teacher for improvement. In this context I visited Schools of Education (mathematics) in three universities in England namely King's College London, Cambridge University and University of Nottingham to observe how student teachers taught the Investigatory approach so that they would be able to use this approach in teaching mathematics to the school children. In King's College I attended all the PGCE sessions in the School of Mathematics Education. I prepared an Observation Schedule and recorded my observations.

4. My observation of Investigatory approaches during secondary teacher training in three British Universities 4.1

Examples of sessions observed:-

The following are the examples of the observed investigatory approaches in three different universities in England.

1) On 21 Oct 1997 from 9.30 a.m. - 12.30, a session with title 'Using and applying mathematics & investigations' in PGCE of Gill Close was observed in King's College, London.

Gill started the session with seven aims regarding the abilities that the trainee is expected to acquire after the session along with three general aims and links such as linking with their own lesson preparation, identifying students' errors and linking to instrumental and relational learning. The task was 'Looking at Number Patterns using Octagon Loops' that led the trainees to investigate and find a rule to calculate the number of free edges in the next loop before making the loop.

Five types of materials like octagon tiles, octagon template, starter sheet ... are used and in the process student teachers participated in seven activities. In this approach teacher exposition, whole class discussion, individual practical work & informal discussion, investigative work, discussion in pairs, small group discussion, student presentation and ultimately whole class discussion techniques were employed. Though it was a session on 'Investigations', an investigatory approach was followed.

At the end of the session to make the trainees realise the importance of an Investigatory approach in using and applying mathematics and to know to what extent the trainees would be able to use it in their teaching, questions of the following type were asked.

Why is it important to work investigatively?

What should we teach through investigating?

Think how you can include an investigative approach into your pair teaching in school within the next 3 sessions.

2) On 24 Nov. 1997 from 9.00 a.m.-12.30, a session with title 'Getting to know Calculators' Investigation on Calculators, in PGCE of Kenneth Ruthven was observed in the School of Education, University of Cambridge. Calculators with different calculating logic and work sheets were given to all the PGCE students and certain tasks were given for exploration of the use and applications of calculators. Cognitive conflict was used in the investigatory approach. The session started with a common starting

point 'Getting to know calculators' with teacher exposition. Then the investigational activity was given. The task given was: 'predict the result $3 + 4 \times 5 =$ when you use your calculator and test your prediction, predict the result $80 + 15\% =$ on your calculator and test your prediction, What are the largest and the smallest numbers can you make on your calculator, What happens when you subtract the smallest from the largest number?', multiply the smallest by the largest number on your calculator, explore these features and other features of your calculator,' and so on. Since the calculators use different logic, individuals got different answers. Students thought about individually and wrote their responses. It was followed by pair discussion with written responses, followed by small group discussion and subsequently whole class discussion. Observations were discussed and generalisations were made.

3) On 2 Dec. 1997, from 9.00 a.m. - 12.30 and from 1.30 p.m. - 5.00 p.m., sessions on 'Exploring Statistical Data using Computers' in PGCE of Malcolm Swan were observed in the School of Education, Nottingham University. Sessions were started with teacher exposition. Statistical data were given on different Real programs to all the trainees to explore, e.g. "Accidents", "Nations", "Sports", "Shirts". Work was differentiated due to trainees' expertise. Additional resources (suggestions for a 'lead lesson', work sheet for students who get stuck ...) were provided. Trainees worked on computers in pairs. They explored the statistical data in various ways, including using statistical graphs, and made many interpretations and suggested solutions to the problems logically with statistical evidence. Techniques like discussion in pairs, whole class discussion, students' presentations were used.

4.2 Summary of University Observations:-

After observing six sessions (three in King's College London, one in Cambridge and two in Nottingham Universities), I found tentative answers to my first question, 'What are the features of an investigatory lesson?' Some important features that I observed were:

- a) Cognitive Conflict was promoted by providing situations leading to different reasoning.
- b) Always there was an attempt to know how the trainees were thinking, what was happening in their minds, why they selected a particular strategy, why some of the trainees used alternative strategies.
- c) There was a continuous diagnostic assessment of trainees' understanding and misconceptions, which informed interventions.
- d) The focus was on processes and application of the content, but not the content alone.
- e) An attempt was made to know how the trainees were relating their previous mathematics knowledge to unfamiliar and challenging situations.
- f) Through individual, pair, group and class discussions the teacher observed how the trainees explored the given data and the mathematical reasons behind them.
- g) Throughout the sessions trainees were facilitated in thinking mathematically.
- h) In some sessions, in addition to following an investigatory approach, such an approach was also advocated and at every stage questions were asked to make the trainees realise why a particular

Strategy was used.

- i) In all the sessions I observed the teachers behaved as an investigator, enabler, facilitator, questioner, listener, observer, a positive evaluator and a communicator.

5. My school visits

In order to obtain an answer to my second question 'What factors facilitate trainees' use of investigatory approaches?', I visited three schools in which King's College trainees were placed. These schools were categorised as A, B and C according to the schemes that they are following. In school A, CAME, GAIM and DIME are being followed. In school B, SMILE is followed, whereas in school C, SMP, STP, Task mathematics and Causeway books are followed. I gave a questionnaire to evaluate the impact of College and phase A on Phase B (Phase A is 1st placement- pair teaching or group teaching and Phase B is long teaching practice for the whole class) to the PGCE (mathematics) students of King's College London.

- a) In school A I saw: 4 SMILE lessons, taught by 3 different teachers, each with 2 King's college trainees supporting them, and a meeting of the mathematics mentor with the four trainees.
 - b) In school B. I saw: 5 whole class lessons taught by 3 different teachers, each with 2 King's College trainees supporting them and a meeting of the mathematics mentor with the 4 King's College trainees.
 - c) In school C. I saw: 4 whole class lessons taught by 2 different teachers each with 3 King's College trainees supporting them; One lesson in which the 3 King's College trainees were working with 3 pupils, 1 teaching, 1 helping and 1 noting the observations; and a meeting of the mathematics mentor with the 3 King's College trainees part of which evaluated the trainees' teaching of the 3 pupils.
- 1) The 8 whole-class lessons were focused on content, using either text books or work sheets. The ninth lesson was on revision of the previous lessons. Only features b), c) and part of i) were observed as teacher trainees associated to evaluate and assist pupils.
 - 2) In the SMILE lessons some pupils were doing investigations but working alone, infrequently benefiting from discussion with peers or teacher intervention. During teacher / pupil interaction features b), c) and part of i) were again observed.
 - 3) In the mentor sessions, one focused on planning materials for SMILE, another on teaching materials including using games, and the other on diagnosing weaknesses of the 3 pupils taught who were very able.
 - 4) The commitment of the schools to CAME, Task Mathematics and SMILE suggests intervention investigatory approaches as do some comments and actions of mentors. 6.

Findings from Questionnaires

The information obtained from the 34 filled in Questionnaires by King's College PGCE (mathematics) reveals that

- a) 21 trainees listed 3 important misconceptions and 13 listed only one or two that they identified either during their teaching or from oral or written diagnostic assessment, 7 out of 34 did not suggest measures to be taken to overcome.
- b) Nineteen of them have given diagnostic assessment for the lessons ranging from 1 - 4, others have listed the misconceptions from their observations.
- c) 20 of the trainees mentioned either they used cognitive conflict or they are planning to use it. , Probability', 'Estimations' are few examples where they used cognitive conflict Some refereed CAME lessons where they used cognitive conflict.
- d) Four trainees stated that they cannot say the best lesson among what they taught where as 11 trainees attributed the investigatory approach (directly or indirectly) for their best lesson and rest of them attributed to the teacher exposition and explanation. 'Symmetry', 'Decimals and numbers on a scale', 'Enlargements' are few examples where trainees followed investigatory approach.

7. My dilemma

Whether it is India or England, what I have observed is the gap between the expectations in teacher training institutions and happenings in the schools. Still the following questions are worrying me.

- a) It is universal and everybody accepts the merits of the Investigatory approach. Then why is it not given enough emphasis in school teaching?
- b) Is it because of the presence of the long time existing approaches in the schools?
- c) Is it because of the belief in philosophy that is crept in the school?
- d) Is it because of the belief of trainees in the approaches through which they were taught at the school? e) Is it because of the University sessions are very idealistic?

I have my own opinions about them but I do not have empirical evidence. So I would like to share your ideas, experiences and opinions in this regard. I would welcome feedback and suggestions for this research.

8. Implications for teacher training in India

On the basis of this discussion I would like to set assignments in India on the following issues.

1. Planning some investigatory approaches initially for Secondary school Teacher training to teach topics like arithmetic progressions, permutations & combinations and data handling systematically evaluating their take up by trainees in schools.
2. Planning some investigations for Primary school Teacher training to teach topics like exploring rational numbers, irrational numbers and decimal fractions.
3. Planning investigations based on patterns, mathematical structures like 'jumping frogs' for recreation and to create interest in algebra. Instead of Computer package in India we may use red and green counters.

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