Understanding Mathematics' Classroom Processes

What Makes a Class "Innovative"?

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Abstract

This paper makes an attempt to study a mathematics class and analyse some of the classroom processes that make the class innovative. The data has been collected from an organisation named 'Digantar' in Jaipur. One class of this school was selected and mathematics lessons of this class were observed along with interviewing the teacher. Apparently, innovation is a subjective term and it is difficult to say whether something is innovative or not. However, it was observed that some of the practices made the class completely different in a positive manner for learning mathematics. This included multi-grade and multi-age teaching, providing students the power to decide what and how to learn mathematics, a unique way of giving feedback and most importantly the algorithm teaching. Some of these practices can be used in any class and by any teacher without being in an 'innovative setting'. The purpose is to make mathematics learning a meaningful activity for students.

INTRODUCTION

Mathematics, as a subject, is considered to be abstract in nature. It is mainly seen as a set of tools that includes certain facts, rules and procedures. Various teachers and educationists make an attempt to reduce this abstractness for young learners. However, the ultimate goal of acquiring mathematical abilities pushes students towards mathematics that hardly makes

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sense to them. It would not be wrong to say that only a few people perceive mathematics as an interesting and thoughtful subject. Dhankar (n.d.) further discusses the nature of mathematics as: 'The mathematical concepts form rather strictly defined hierarchies. A missing link in the hierarchy is sure to hamper the formation of all the concepts above it in that hierarchy'.

India is one of the countries where students receive education primarily in a school setting. Consequently, classroom processes cannot be overlooked while taking decisions about teaching any of the subject, specifically mathematics.

Classroom processes might include many aspects like class size, classroom culture, interaction between students and teachers, teacher's conceptions about students' learning and subject, etc. The quality of a dialogue taking place between teacher and student depends on how these processes are implemented in the class. Participating in the processes of a mathematical classroom suggests participating in a culture of using mathematics, or a culture of mathematising as a practice (Bauersfeld, 1993). Bernstein's (1971) idea of framing is quite meaningful to understand the classroom processes in a mathematics class. He discussed two types of framing: Strong Framing and Weak Framing. Strong frames reduce the power of the pupil over what, when and how one receives knowledge and increase the teacher's power in the pedagogical relationship whereas weak frames give power to students to take decisions about their own learning.

The idea of classroom process becomes even more necessary when we discuss innovation for a particular subject. Defining innovation or declaring any class as 'innovative' is really difficult. This term seems to be subjective and context-specific as a single initiative or classroom practice used by any teacher in her class can be called innovative. For example, if a teacher asks students to play a game of making rectangles of dimensions based on the numbers that appeared on two dice can be called innovative. However, one cannot be sure of calling the same classroom as innovative keeping the regular classroom processes in mind. Therefore, it is necessary to consider other aspects and the regularity of the same. Innovative pedagogy follows when the concept of innovation is nurtured in educational setups. Innovative pedagogy gives rise to innovation in educational context (Tyagi, 2018). Boaler (2002) discussed about innovation in mathematics classroom based on her study as: 'The students were engaged in activities and projects in which the need for certain mathematical method becomes apparent. This approach necessitates a relaxation of the control teacher has over the structure and order of the classroom.'

This paper presents a part of the research conducted to study

classroom processes in two contrasting schools. The study focused on many aspects including teachers' beliefs, classroom culture, students' work, etc. However, the data used in this paper discusses only the processes that take place in an innovative classroom. This data has been collected from 'Digantar' organisation, Jaipur. Digantar has been working in the area of providing quality education for approximately 35 years. It is involved in school education, publication, teacher education and many more. This paper tried to understand some of the classroom processes that make a class innovative and meaningful for learners.

Objectives

The main objective of this paper is to:

- study those classroom processes that can be kept in the category of innovation.
- analyse the reasons of calling them innovative practices.

Methodology

One group (called 'Samooh') was selected as a sample to study classroom processes in Digantar Vidyalaya. The rationale of selecting this school was based on the background of the students as all the students come from a lower socio-economic status and these students are unable to pay the fee. This study conducted qualitative inquiry of a mathematical class to understand what happens in a class that can be called mathematically meaningful. Classroom observations, interview schedule and students' work were used as the tools for data collection. Twelve lessons were observed and the class teacher was interviewed at the end of all the observations.

About the Class

This class had 25 students and all students came from lower socio-economic background. It was found that there was no fixed timetable for any subject. Teaching of all the subjects took place every day. The students called the teacher by name like 'Manoj ji'. Students used workbooks based on their level to study in the mathematics class. They could use material to understand the concept and to solve questions given in the workbook. The children were found sitting in groups of three to five along with their workbooks.

What Makes the Class Innovative?

As we have already discussed that innovation is a subjective term; however, we will be discussing some aspects that contribute in making the class innovative and meaningful in the context of mathematics teaching and learning. Here, those aspects will be supported with some instances from the class by using some pictures.

No Class-wise Distribution (Multi-grade and Multi-age aspect)

The most important point that makes any of this class in this school innovative is having no class division.

Group 1 selected for the study did not belong to any particular class grade. One cannot assign levels to the Classes III, V or I because all the students of various age groups studies together in one single room. The groups were given names as collectively decided by the students for their class for instance, a group was named as 'Aman Samooh'. There were other *samooh* (classes) also like 'Geet samooh', 'Asha Samooh', etc. The philosophy of giving chance to students to work on their pace was followed in this setting. Students could be seen sitting in different small groups and doing similar or different work appropriate for their level. No student is asked to be at par with one's counterparts. Their learning levels were assessed individually and compared with their own previous progress in different learning areas.

Students in these two pictures are working in groups. Picture 1 is of the class that was selected for the study. Picture 2 has been taken from internet.

The teacher of this class also had a positive view about this arrangement. He shared about his students' learning as follows:

"Ab jo baccha jis star ke anusar hai to uske purv gyan ko dekhte hue mere bacche ko pehle itna aa chuka hai uske hisab se ab kya aana chahiye usko dekhte hue use aage badhana chahiye.('Keeping in mind the present level of child and his or her previous knowledge of the subject, the child would be motivated to learn the concept accordingly').

'Pehle ye dekhna hoga ki hamne ab tk kya sikhaya aur iss target ke adhar se mera bacha kahan pahuch paaya aur phir us target ko dekhte hue main naya target tay karunga'. ('Firstly, we need to see what has been taught to children till now and where have they reached. Considering that, their current and future targets will be decided.')

(*Courtesy:* Digantar)
(*Source:* https://www.google.com/search?q=digantar&sxsrf=APq-WBvO6I9cEVIgyCLY0E2DtwjYNwOnKQ:1647425298108&source=lnms&tbm=isch&sa=X&ved=2ahUKEwie47-9scr2AhUoT2wGHe-QBAcQ_AUoA3oECAIQBQ&biw=1366&bih=617&dpr=1#imgrc=mQd8iqUM5vSndM)

These words clearly show that the teacher understands the importance of children learning at their own pace. Kyne (2004) in his article titled 'Teaching and Learning in Multi-grade Classroom: What Teachers say' stated that 'The multi-grade class, according to teachers, provides a wholesome and friendly classroom atmosphere in which the social and emotional development of pupils, as well as their academic progress, is promoted.' With reference to mathematics also, the idea of multi-grade seems important since mathematical concepts are hierarchical in nature and students reach the higher grades without understanding the basic concepts and face issues in mathematics at middle level. According to ASER (2016) report, only 43.3 per cent of Class VIII students can do a 3-digit by 1-digit division problem correctly. One of the reasons could be the compulsion of doing mathematics at par with other students even when the child is not able to achieve the basic understanding. This issue might not arise in a multi-grade class and students will get more time to study a concept depending upon their level.

Freedom to Learn and use Material

The second aspect contributing in a class being innovative is the freedom that is provided to students when they want to use material and choose their own way of learning. The following is the example of what was happening in that class on a specific day:

- A girl was holding workbook in her hand and counting with pebbles on the floor in order to solve addition sums given in the book.
- A boy was sitting in the centre and the teacher was discussing the concept of grouping, using the bundle of sticks.
- A girl and two boys were standing near the blackboard, whereas one boy was explaining the concept of multiplication to them.
- Three girls were measuring the parameter of the class and recording their observations in the workbook.
- A boy and a girl were debating over their solutions of multiplication calculated by using repeated addition and direct multiplication methods.

Similar kind of work could be observed occurring simultaneously in the class during mathematics period.

As we can clearly witness that students are freely doing their work and supporting each other, peer learning also becomes prominent in this class. Students' interaction with the material seems to improve their mathematical learning because students also noted the results they observed with material. The teacher was seen performing several roles while teaching like providing hints or prompting children. During observations, the teacher went to several students, discussed the concept with them and prompted

them in the direction of forming mathematical concepts. In another observation, the teacher asked students to bring fake currency and form the amount made by the child. The teacher also helped him in this process as follows:

Teacher: '*Achha jaise ismen hai ki baawan (52) rupees banao to kaise banaye*' (It is given to make rupees 52, so how will we do it?)

Student: '*Dus ke do note*' (Two notes of rupees ten)

Teacher: '*Achha nikalo ismen se*' ('Okay take it from the box')

The boy took out two notes of ten rupees.

Teacher: '*Ab*' ('Now')

Student: '*Ab Paanch paanch ke chhe note*' ('Now…six notes of five rupees')

Teacher: '*Wo bhi nikalo*' ('Take them out too')

The student took out six notes of five rupees and said

Student: (Keeping all the currency in hand) '*Ye ho gae pachas...aur ab ek ek ke do aur*' (Now it's fifty and we only need two coins of one rupee)

Teacher: '*Wo bhi karo*' (Do that)

Teacher: '*Yani 10* ₹ *ke do note, 5* ₹ *ke chhe note aur* ₹1 *ke do* (That means two notes of ₹10, six notes of ₹5 and two coins of ₹1)

Teacher: '*Kya kisi aur tarike se 52 bana sakte hain*' ('Can we make 52 using any other combination?')

Student: '*Haan*' ('Yes')

The given example shows that material like fake currency is being used in a meaningful manner and support children in visualising the mathematical concept of adding facts. Such experiences help children understand that there are multiple ways to reach the solution in mathematics which can be discovered by them. Boaler (2002) also shared in her study that when teachers teach mixed ability groups, they find various ways to differentiate materials using open-ended materials that enable students to work in different directions and levels. Therefore, when multi-graders interact with material in their own ways, it makes mathematics meaningful for them. The classroom discussed here has used Bernstein's idea of framing, and we can say that it has weak frame as students have the power to select what, when and how they want to learn. The teacher's role is mainly to facilitate students in that process. The given picture of the class demonstrates the free learning environment, where students and teachers both are focusing on their respective works.

The students are not facing towards the blackboard when the

teacher is writing, whereas in a regular classroom, one can hardly find this situation as students are expected to look at the board and follow the teacher writing each word. Here, students are involved in discussion with their friends.

Algorithm Made Meaningful for Students

The two aspects discussed about multi-grade teaching and freedom to use material were not only limited to mathematics but also used in all the subjects. In other words, we can say that these aspects were a part of the philosophy followed by the school. However, a aspect of algorithm teaching is very much specific to a mathematics class. Algorithm is basically known as the step-by-step procedure of doing anything like making a cup of tea or reaching another city. But why are we saying that this idea is specific to mathematics is because students in early grades start using algorithms to solve problems of various arithmetic operations. Almost every person has studied these algorithms in the school and chances are that they just memorised the procedure without visualising how the algorithm actually works. Algorithms are one of the reasons that make mathematics abstract in nature. The way of teaching algorithms in this class was developed by using the mathematical problem. The students were given a chance to visualise the problem and solution was provided in the form of algorithm, as done in the example given below:

The teacher wrote a problem of 28÷7= on the board and started explaining one student

Teacher: 'Maan lo 28 aam hain hamare paas..Kitne aam hain?' (Let's assume we have 28 mangoes. How many mangoes?)

Student: "Athaais" (Twenty-Eight)

The teacher drew 28 small circles on board for mangoes.

Student: "Saat saat baant do" (Distribute seven and seven)

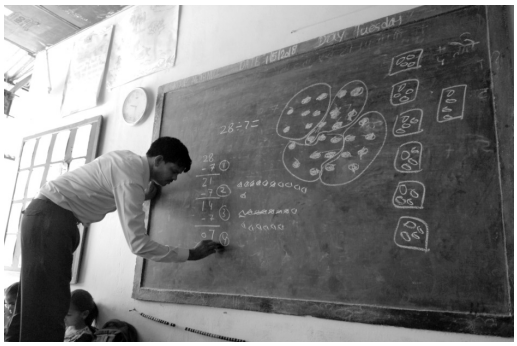
Teacher: "Ab kya karen 28 aam hain hamare paas kitne bacchon mein bantna hain saat mein" (What do we need to do if we have twenty eight mangoes. How many children are to be given it? Seven)

Student: "Saat mein" (In seven)

Then teacher drew seven boxes in one corner of the board and started distributing one by one every time saying "Kya aur bant sakte hain?" (Can we distribute more?) and also saying after distributing "Kya sabko barabar mile? (Did everyone get equal mangoes?)

Then he asked the student three times "Kya sabko barabar mila?" (Did everyone get equal?) and" Ek ko kitne mile?" (How many did one child get?). The student also responded to the questions with "Yes" and "Chaar" (Four).

Then the teacher explained the same problem using equal grouping and at the end, using repeated subtraction in vertical form of division, as shown in the picture given below.



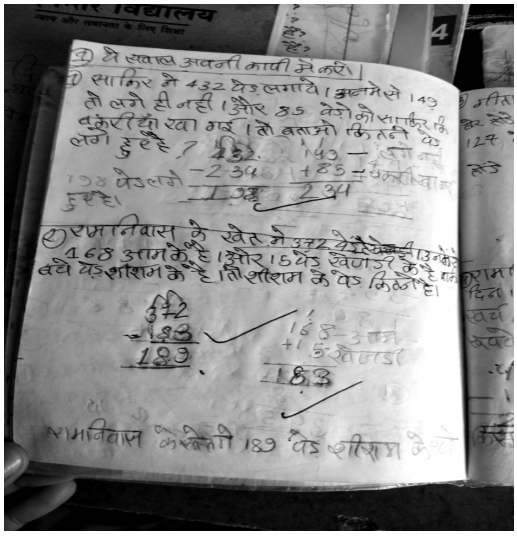
The teacher here provided three methods to solve a division problem and left it upon the child to choose any method or develop his or her own method. The possible methods of solving a problem were discussed by the teacher and the students were provided options to choose a method that suited them. In another lesson, the teacher discussed the reason of dividing with the left most number (Hundred's place in a three digit number) first in division algorithm with the help of fake currency. Carraher et al. (1987) analysed the oral practice in detail and described a general strategy of decomposition to solve addition and subtraction problems and repeated groupings for solving multiplication and division problems. Verbal methods to solve mathematical problems also give students the confidence to use mathematics in their day-to-day life.

Replacing cross sign with a dot for wrong solutions

Whenever it comes to solve a number of mathematics problems in the notebook, majority of students try to avoid using cross sign in their notebook for wrong solutions. Irrespective of grade or level, teachers check the mathematics notebook and put big cross signs with red pen for wrong solutions on every student's notebook. The psychological theories which put great emphasis on children's errors and mathematical errors could be treated as a great tool of learning students' mental processes but a student is always expected to write only correct solutions for the sums.

When students' notebooks were studied to analyse the feedback provided by the teacher, it was observed that the teacher had put only a check mark on the correct solution along with his signature on every page. There were no wrong answers in the notebook but a point could be seen marked in the notebook by the teacher to communicate that there was some problem in the sum and the student might correct it once found. One could see the solution erased by the child and correct solution rewritten on it. That might be the reason for having no wrong answer in the workbook. The following picture can be seen as an example of how the teacher put a dot on the incorrect solution and the child reviewed one's answer and provided the correct solution by oneself or with the help of the students or teachers.

The teacher's way of communicating that a student needs to review one's solution seems to be a great way of teaching mathematics



without creating any negative emotions about mathematics in children's minds. Schleppenbach (2007) discussed the importance of students' error in mathematics as: 'Some teachers sought to create such an environment by telling the students not to feel afraid of making errors and by acknowledging "good mistakes" that are useful in instruction.'

Conclusion

Classroom processes in a mathematics class become even more essential when studied in an innovative class where certain aspects like multi-grade and multi-age teaching, use of teaching learning material freely, deciding upon what and how to learn mathematics and communicating the error in a positive manner, play a key role. It is also important to look at any classroom with multiple perspectives as it has been done here, where we tried to understand the classroom processes from the perspective of innovation, mathematical capabilities, teacher and students' role, etc. Even though this was a single class, it tells us a lot about mathematically meaningful activities. Keeping some basic child developmental theories in mind, any class can be transformed into a completely different one like by using multi-grade teaching and giving freedom to use material in class enables students' individual capacities to grow at their own pace. Evidently innovation can take place in any class but it depends on the teacher, how he or she wants to deliver the concept when system provides them the freedom to use all the available and possible strategies.

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