

Stories and Mathematics Come Together

Abstract

An Elementary school teacher explores the use of storytelling as a pedagogic tool for teaching Algebra to her students. She discusses various sub-concepts of Algebra that are embedded into the story and the students attempt the associated worksheet. Then she discusses their textbook questions to give more practice and different contexts. Students' response to the story and the associated tasks are heartening because of high curiosity and logical reasoning shown by them. Their agency in using all their resources to help someone in need is also very powerful. Storytelling is worth a try for teaching a subject that is usually seen as 'difficult' by some students.

The bell rang; it was time for the maths class. There was a sudden excitement in the children. The English teacher present in the class was rather surprised. "What's wrong? Why are you in such a hurry?" she asked. "Niki* ma'am will continue with the story today. Can't wait to meet her", one of them replied. The teacher said, "What! ...story in a maths class? That's new!" Just for curiosity, the English teacher waited outside the class. As soon as Niki, their mathematics teacher entered, the children surrounded her with many questions such as, "Ma'am today will you tell us if Alice found White Rabbit or not?", "I want to tell you something about my 'no- sense' world", "Will you give us more puzzles?", "Will we help Alice again?", "I want to show you something..." and many more.

Niki told the class to settle down and then began with the day's class.

As you would have gathered, Niki is using a powerful tool for teaching mathematics to her class 6 students, the idea of telling stories. Before I tell you more about Niki's classes let me

take you a little behind time, a time when Niki was not such a popular teacher.

Not long ago, Niki's classes were like any other traditional math classroom loaded with lot of black board work, paper pencil tasks and discussions centred around the textbook only. She used to do maths activities with her students but the classes were rather dull. Niki had already started to feel burnt-out, just after 3 years of teaching. She felt her classes were not exciting. She wanted her students to enjoy doing maths and the idea of doing only materialistic activities was not exciting her students much. Recently, she had met a research scholar who wanted to work with an in-service teacher to conduct an intervention in order to explore the use of stories in teaching mathematics to elementary school children. When Niki got to know about this, she was curious and agreed to collaborate with the research scholar (Neena).

To start the intervention, Neena began by discussing the idea of using story telling as a medium of doing mathematics. To build Niki's confidence Neena also shared with her many

*All names in the study are pseudonyms. The author wishes to thank the Principal of the school, the teacher and the students of the class for their cooperation in collecting data for this study.

readings related to it (for example, Schiro (2004), Egan (2005), Zaskis and Liljedahl (2009)). Niki was excited and wanted to try them out with her class. She had apprehensions because she had never imagined this as a possible way of teaching mathematics. She had never before narrated a story to her students and had not encountered any such strategy during her teaching training. Neena told her that this pedagogic tool of storytelling had been successful in primary classes but using it in elementary grades was an unknown territory. In other words, they were going to find out its effectiveness together.

School and the Students

The school where this intervention of using a story in a mathematics class took place was located in the East district of Delhi and was an all girls' school. The majority of students belonged to a religious minority group. The class had a total strength of 32 students, out of which 20 remained present during all the story sessions. The medium of instruction was Hindi.

The Teacher

Niki had been working with the school for the last three years, teaching mathematics to middle school students. She had completed a One-year teacher training course from a Central University.

Concept and the Story

Neena and Niki met a number of times in order to prepare for the intervention. First they had to finalise a mathematics concept appropriate to the level of the class. Niki said, "Algebra is a very important topic for the elementary grades and students find it quite boring. Let's teach it with the story" Neena agreed and they decided to teach algebra to the class. Next, was

deciding an appropriate story. For this, Neena spent many days in the class observing students and suggested the story of 'Alice in Wonderland' written by Lewis Carol in the year 1865. She cited several important reasons for this. One, the protagonist in the story is a girl who is almost same age group as Niki's students. Secondly, the character lusts for changing the real world. Often children of this age group (class VI) fantasise such ideas. This would get the students excited and they would open up in the class. Thirdly, the story has many characters and a long plot. These would give scope to embed many mathematical ideas in it. Neena discussed these parameters with Niki and for familiarisation Niki was suggested to read the novel. Meanwhile, Neena decided to adapt the story by making certain minor changes. She framed a story with a similar plot, but with many opportunities to learn and practice algebra. Some situations of the original story had to be changed for the purpose of teaching. She used their NCERT Mathematics text book for Class 6 (NCERT, 2009) for the flow of ideas and the range of questions. Reason for this was that her concern was to stick to the mathematics concept and the textbook while using the pedagogic tool of storytelling. Thus, the mathematics concept and the related questions in the story classroom would be the same as the traditional classroom. It would be easier to understand the students' learning this way. Niki and Neena held long discussions about the flow of story and the mathematical concepts embedded in it. They embedded sub-concepts of algebra within the story. Some key sub-concepts that were to be covered via story were finding a pattern, forming a rule for a pattern, using a variable, solving an equation. Next, they worked on designing the worksheets that would be embedded

into the story and would be solved by the students for helping Alice. The story of 'Alice in Wonderland' was split into 7 sessions with 7 corresponding worksheets (Please see Table 1 for details of the 7 story sessions).

	Algebra Subconcept	Mathematics Task	Story Flow
Session1.	Finding the unknown numbers	Open-ended Number puzzles	Alice had to open the door of the burrow to follow the White rabbit. The door knob directed her to chits of number puzzles in order to find the key.
Session2.	Deciphering a pattern and extending it	Worksheet with questions on shape patterns using matchsticks	When Alice lost hope of following the White Rabbit she cried and cried and cried. Her tears turned into an ocean and little animals got trapped in whirlpools of tears. Alice had to help them get out by finding matchstick patterns and extending them.
Session3.	Pattern recognition and extending it	Questions on number patterns	Tweedle Dee and Tweedle Dum showed Alice the In and Out Machine and she had to study the pattern and find the correct numbers to be entered. They then showed her the way to find the White Rabbit.
Session4.	Introduction to a variable	Worksheet on finding cost of 'n' things. (Fig.1)	White Rabbit wanted help on finding the cost of 'n' different articles in his store because he was being duped of money. Alice was to help him.
Session5.	Using variables for Word problems on practical situations	Writing expressions using variables for age of relatives in a family	Cheshire cat was puzzled by the age puzzles and she asked Alice for solving them. In exchange she offered to tell her where to find the White rabbit.
Session6.	Balancing equations	Finding the unknown number in order to balance a see-saw	Alice was sent to the Mad Hatter's tea party. There they could not keep the tables steady because it had a support only in the centre, like a see-saw. March hare had to place the correct number of cups on both sides to balance it. So Alice helped him in the hope of finding the White Rabbit.

Session 7.

Finding solutions of equations

Equations in one variable and three options as possible solutions were given to students for finding the correct one.

Alice met the White Rabbit at the Queen's palace and got into an argument with her. The Queen challenged Alice to a game of finding solutions to equations. Alice took it in order to save the lives of her innocent friends who were to be hanged for making a small mistake in finding solution of an equation.

1. कैलनों के मूल्य का हिस्सा

कैलनों की संख्या	1	2	3	10	m
मूल्य	₹ 15	₹ 30	₹ 45		

2. गोंद के मूल्य का हिस्सा

गोंद की शीशों की संख्या	1	2	5	10	15	a	b	100
मूल्य	₹ 10							

3. अणकों से कैलनों का हिस्सा

अणकों की संख्या	1	2	3	5	7	11	a	e
कैलनों की संख्या	5	10						

4. कंचों के डिलों का हिस्सा

डिलों की संख्या	1	2	10	15	p	q	r	100
कंचों की संख्या	7	कंचे						

5. अणुओं का मूल्य (दण्डों के हिस्सा में)

दण्डों की संख्या	1	2	5	u	v	z
अणुओं का मूल्य	₹ 25	₹ 50				

6. अलखड़ी की अणुओं और गोंदों की संख्या

अणुओं की संख्या	1 अणु	2 अणु	3 अणु	3.5 अणु	5 अणु	x अणु
संख्या	2 अणु					

7. कैलनों के मूल्य का हिस्सा (दूर जान)

अणुओं की संख्या	1	2	3	5	x	y
मूल्य का मूल्य	₹ 10000					

8. अणुओं का हिस्सा (दूर जान)

अणुओं की संख्या	3	1	6	9	e	f
कुल का मूल्य	₹ 10000					

Before launching, Niki practiced the skills of telling a story with Neena. Neena had requested Niki to write reflective journals (RJ) at the end of each session about her experiences with children during the intervention.

Intervention

After 12 days of practice and shared discussions, it was time to hit the floor. Niki arranged for two consecutive periods for ten working days. The story sessions were planned for seven consecutive days with three extra days for just in-case situation. Niki told the class about Alice who wanted to live in a world which made no sense at all. The students were surprised. Niki asked

them, “What kind of a world do you want to live in?” The girls were quite for a long time. Niki told them about her own world. She said, “In my world money will grow on trees and there will be no schools”. This is when the girls started speaking up. They had so many things that they wanted to realise in their world. The story of Alice had started to interest them because they expressed excitement in following her through her adventures.

Now let us go back to the class that we described in the earlier paragraph. In the session 4 (Table 1) Niki had planned to discuss the use of a variable, and this is how she did it. In the story situation, Alice was trapped

in the house of White rabbit and he had put a condition for her escape. He said that Alice must help him in some calculations because he had been facing losses in his business recently. He had prepared a sheet (worksheet for the students) in which some calculations needed to be filled in. He said that he did not know how to calculate the respective figure when the given was any arbitrary number instead of a specific number. The sheet, is shown in Figure 1. The students were to calculate the costs, numbers of stairs, income tax, etc. for any given variable after looking at the previous pattern given in the table. This sheet was inspired by their NCERT text book (Class VI, pg 226 and 227). It introduces students to the idea of a variable.

Niki gave the students the sheet and told them to first explore it. Meanwhile, she also drew the table on the board. After a few minutes, she asked them about what they had to do in it. Most of the students said, “We have to fill in the blanks...”

After some brief discussion the students said that multiplication was giving the costs in the second row. Teacher gave them more number of books to calculate the cost so that they could generalise the pattern of multiplication. Finally, she raised a question, “What if there were ‘j’ number of books, what would we do then?”

There was pin-drop silence in class because dealing with a literal, instead of number was new for the students. Teacher prompted, “What did we do before, with 1, 2, 3, 10 number of books...?”

S1: We had multiplied...

T: So here also we will do that...15 multiplied with j

She wrote this on the board as ‘15 multiplied with j’ and added the unit of ‘Rupees’ in the front. Then she refined

it to ‘Rs. 15j’. She extended the table on the board with more variables and numbers for practice. Then she asked the students if they will attempt the rest of the tables to help Alice. They were very enthusiastic and immediately got to work. Niki told them to attempt the sheet on their own first. The plan was to discuss this for two days and the next day she wanted to give them feedback and practice the questions from the textbook.

The students’ work showed that they found no difficulty in completing the first 5 tables because they were based on multiplication alike the first example. Students discussed with each other the pattern involved in the tables and then predicted the next number after multiplying. For the variables they repeated the rule that the teacher had mentioned. Most of them had also written the units along with the variable. This means that the students were reasoning about the rule, applying it and at the same time maintaining the context of the table. According to Niki, students had been able to do the questions very fast and when she reviewed their answers later, the degree of accuracy had also improved. In her daily Reflective Journal (RJ) she wrote, “The students have reasoned correctly. Also, I feel, earlier I had to tell them to finish their work fast. Now, in order to help Alice, I can see that they use time as a precious resource. Their work has urgency and at the same time accuracy”(RJ p. 7)

After doing the first five tables, the sixth, seventh and eighth tables were designed to pose mathematical challenges to the students. The sixth table was related with calculating the number of stairs for specific heights. There was a new figure of 3.5 meters. This had to be multiplied with 2 to give the number of stairs required. Most students were able to find the pattern

as they wrote '2x' for the variable. However, Niki found that no child could multiply 3.5 with 2 correctly. Many of them gave varied responses to this. Most common response was, '6.5 stairs', meaning that they knew that a factor of 2 was required and so they wrote 6 but did not know what has to be done with the decimal part, i.e '0.5'. One student wrote '6^{1/2}stairs'. This shows an understanding that though that student knew '0.5' was same as '1/2', she did not know how to take it further. One student expressed the product as, '6:30 stairs'. This expression shows an amalgamation of representation of time and number. Another student wrote '610 stairs' which reflects that this student had neglected the decimal part and had multiplied 35 with 2. The range of responses shows that students were open to attempting new questions by constructing on their previous knowledge, giving reasons for the possible answer.

The seventh table related to the yearly electricity bill. As per the story, these tables were related to the business of White Rabbit. Even though this was similar to the previous problems in terms of multiplication operation, the students found it difficult to work with large number like 10,000. Only 11 out of 20 students could do this correctly. The argument of having problems in dealing with large numbers appears valid in light of the correct responses in the previous questions.

The eighth table was on calculating Income tax. Here the students were given the tax for three years as Rs. 9000 and they had to calculate it for 1 year first before calculating it for others. After calculating the tax for 1 year as Rs. 3000, the students had to multiply each entry in the first row with 3000 to find the respective tax in rupees. This question was attempted by 14 students, out of which only 8 gave the correct

answer as 'Rs. 3000e'. Some students had not done the necessary calculation for 1 year and wrote the tax for 'e' years as 'Rs. 9000e'. Some calculated the tax for 1 year as Rs. 3000, but wrote the tax for 'e' years as 'Rs. 9000e'. One student did the division for 1 year, but has written '3e' as the tax for 'e' years.

The responses of the students showed that they had learnt to use the variable while solving the problem for Alice. They themselves analysed the givens and found entry points to the solution. They conjectured and applied the strategy to the different situations. They made sense of the table entries and located the pattern in them. Every time when Niki asked them to provide the reason behind their thinking the students did so aptly. Niki wrote in her Reflective Journal (RJ, p.5), "I always encouraged the students to provide their reasons, but they appear very eager to explain now. They also seem to be thinking a lot about the problems. They want to know if they are correct and they are asking each other to confirm". According to her, the story had a role to play in this, she said, "I think the first session of the story had set the stage for speaking and communicating in the class and it has helped them in mathematics also (RJ, p. 20)".

Niki reported that the students had started talking to her freely since the story started. Children talked about Alice during the break time and between the classes. They were always curious about White Rabbit. They thought about the problems and challenges at home. One student recreated the sheet of White Rabbit at home with 5 similar problems and showed it to Niki the next day. The engagement with the subject and the high interest convinced Niki that the story was indeed helpful in facilitating teaching and learning of algebra. She said, "Earlier students did not want to do

mathematics for more than one class, but with the story sessions they became more enthusiastic". Students always requested Niki to ask the next teacher for extension of the math classes and they were ever willing to complete any task (worksheet, problem, exercise and problem) during the story sessions.

Stories are a powerful resource to attract and sustain the attention of learners. It also acts as a unitising factor for the class. Niki said that the class behaved like they were working for one single goal, which was to help Alice. They were a cohesive unit collaborating with each other. Students reasoned, solved problems, communicated and collaborated for the sake of the story characters. The example of Niki's class shows that stories can be used to teach mathematics to students. Niki wrote in her journal, "I could not believe that my teaching could involve the students so well. I saw their affection for the story and felt happy that they loved the class"

When Neena asked Niki to explain some of the reasons behind these observations, Niki attributed it to empowerment. She said, "In a story situation where students act as facilitators in someone's life they feel powerful. They feel their actions have a reason, a purpose and that is why their agency is so strong. They feel like they are driving the outcomes of the story and that is why they want to take everything 'hands-on' ". Niki quoted an instance to support this. She said in one of the sessions when students had returned the worksheets, a student asked me, "*Maam, bas itna easy hi tha aaj?...thoda aur do na...kal mushkil dena...*" ("Such easy sums for today?...I want more...get difficult ones for tomorrow") This statement shows that the students were enjoying solving problems and loving the challenges in the story classroom.

Challenges Ahead

The example of Niki's class shows that students' loved the challenges and felt empowered to solve mathematical problems for the sake of the characters of the story. Given the challenges that teachers often face while attracting children towards mathematics, story-telling is worth a try. However, there are some points of caution. Firstly, one has to be careful in planning meticulously for such an intervention because some studies have reported that sometimes students may focus only on the story and might ignore the mathematics completely (Balakrishnan, 2008). So a balance between the two needs to be established and constantly monitored.

Secondly, it is important to provide new problems having different context than the story. This will allow the students to apply the learned concepts in various contexts and the mathematics concept can thus be seen independent of the story situation.

The use of story as shown in this article may look like a time consuming endeavour, but there are a range of stories and innumerable books that can be used for the purpose. One can start by using children's books and many other resources available online. I am providing a list of some to start with.

Resources for Storytelling in Mathematics:

1. http://www.numeracyforallab.ca/uploads/2/6/6/7/26675047/a_trade_book_library_for_k-12_mathematics-2.pdf
2. This link provides a collection of titles that can be used to teach mathematics topic to different classes.
3. *Oral storytelling & Teaching Mathematics: Pedagogical and*

- multicultural perspectives* (2004) Author: Micheal Schiro. Publisher: Sage Publications.
4. This book advocates the use of stories for teaching mathematics and proves it with many examples from primary and middle school.
5. *Teaching mathematics as storytelling*. (2009) Author: Rina Zazkis and Peter Liljedahl. Publisher: Sense Publishers.
6. This book shows how stories can be used in many different ways to discuss mathematics concepts. Examples of stories and students' work have also been given.

References

1. Balakrishnan, C. (2008). Teaching Secondary School Mathematics through Storytelling. Unpublished dissertation. Available at <http://www.peterliljedahl.com/wp-content/uploads/Thesis-Chandra-Balakrishnan.pdf>
2. Egan, K. (2005). *An imaginative approach to teaching*. San Francisco: John Wiley & Sons, Inc.
3. National Council of Educational Research and Training (2009). *Mathematics. Textbook for Class VI*. New Delhi: NCERT.
4. Schiro, S. M. (2004). *Oral storytelling & Teaching Mathematics: Pedagogical and multicultural perspectives*. California: Sage Publications.
5. Zazkis, R. & Liljedahl, P. (2009). *Teaching mathematics as storytelling*. Rotterdam, NL: Sense Publishers.