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Engaging Students with Mathematics Through Story: A Case of Grade II Children

Abstract

The study discusses how a story acted as a catalyst for engaging primary school learners with mathematics as they learned the concept of repeating pattern. Engagement is viewed as a multidimensional construct made up of cognitive, motivational and emotional aspects occurring together. The study took place with 22 Grade II students (8 boys and 14 girls, age group 7 to 8 years) studying in a Government school of Delhi. The teacher in the study was a pre-service primary grade teacher and the study took place during her internship period. Data analysis showed the coexistence of the three aspects of engagement in the mathematics classrooms that used storytelling as a pedagogic tool. Students were engaged with the mathematical content as much as with the story. The findings also delve into the reasons behind students engagement with mathematics.

Introduction

Improving students' engagement in mathematics is a matter of concern for every teacher teaching the subject. Learning takes place when students engage with each other and with the tasks in hand. Fredricks et al. (2004) regard engagement as a multidimensional psychological construct where cognitive, emotional and behavioural components occur together. It explains that for profound understanding to take place it is imperative to engage children in all these three aspects of engagement. In this paper, we have attempted to address how storytelling proved to be an effective pedagogic resource for building students' engagement in mathematical classes.

Background of the Concepts

For the purpose of this paper, we need to consider two aspects:

1. The mathematical content;
2. Use of stories as a pedagogical resource.

Mathematical Content

The mathematical content which has been addressed in this paper and around which the stories were based was the concept of repeating patterns. Repeating patterns are patterns where a single motif or a group of motifs recur at fixed intervals. Liljedahl (2004) and Warren & Cooper (2006) explain that in repeating patterns there exists a discernible unit of repeat that gets generated by repeated occurrence thus creating a cyclic structure. The concept of repeating patterns appears in almost every curriculum of primary mathematics as it lays the foundation for many mathematical domains, such as functional thinking (Warren & Cooper, 2006) and proportional reasoning (Papic, 2007).

According to Warren & Cooper (2006), young children progress through a sequence of steps while learning repeating patterns. These include, copying the pattern or creating a replica of a shown repeating pattern using the same material,

extending a given pattern, identifying the repeating element, completing the pattern by filling the missing parts, constructing a new pattern, and finding structural connections between the patterns.

A first concept that needs to be introduced in learning repeating patterns is the concept of 'unitising'. Lamon (1994) asserts, the process of 'unitising' is the fundamental aspect in learning patterns. Unitising is "the ability to first construct a reference unit (a unit considered as the whole in that particular context) and, second, to reinterpret a situation in terms of this unit" (Warren, Miller & Cooper, 2012). To decipher repeating patterns, it is important for a child to identify the 'unit of repeat'.

Use of Stories as a Pedagogical Resource

Stories have the power to stir emotions, intellect, curiosity and imagination. Stories have been termed as the primal act of the mind (Wells, 1986). Studies investigating the use of stories for teaching mathematics have majorly focussed on stories providing a contextual base for discussion (Whitin and Wilde, 1995), providing problem posing and problem solving opportunities (Casey, Kersh & Young, 2004), improving mathematics related vocabulary (Capraro & Capraro, 2006) and engaging all students of a class, including those with learning difficulties (Courtade et al., 2013). While the Curriculum and Evaluation Standards for School Mathematics (CESSM) (NCTM, 1989) advocates "…the use of children's books as a vehicle for communicating mathematical ideas", Schiro (2004) and Egan (1986) lament that the mathematics that is taught to children lacks good stories. In addition, a recent review of the work done in this area by Flaveres & Schiff (2014) urges for rigorous research in understanding the effectiveness of using stories as a pedagogic tool for improving children's mathematical learning.

This study is a step forward in this direction as it illustrates how a story acted as a catalyst for engaging primary school learners as they learned the concept of repeating pattern.

Sample

The study took place with 22 Grade II students (8 boys and 14 girls, age group 7 to 8 years) studying in a Government school of Delhi. The teacher in the study was a pre-service primary grade teacher (pursuing B.El.Ed course) and this study took place during her school internship period.

Planning for the Study

A story based on a popular television cartoon character was chosen to build the concept of repeating patterns. The narration of the story followed the format of an epic story (Schiro, 2004) wherein a long story is narrated in smaller chunks, spanning across many sessions and in each session a sub-concept, making part of a larger concept, is embedded. As stated earlier the story used in this case was an adventure story based on a popular cartoon character and the mathematical concept embedded in the story was of repeating patterns.

To make a decision on the type of patterns to be used in this study a review of NCERT textbooks Grade II (NCERT, 2006) was done and it was found that till Grade II the children are expected to observe and identify patterns in the world around them, complete and continue patterns in a line or in a plane, and do skip counts of numbers like 1, 2, 3, 5, 10.

The story was split into eight sessions wherein each story session corresponded with various sub-concepts of repeating patterns of the type ABABAB and ABBABBABB, skip counting and elementary ideas of growing and inventing patterns. In each session, one sub-concept related to the idea of patterns was taken. Session 1 and 2 were based on repeating patterns of type AB and ABB; Session 3, 4 covered skip counting; in Session 5 and 6 the students worked on

elementary ideas of growing patterns; and in Session 7 and 8 pupils were asked to invent patterns. Each story session lasted for one hour approximately.

In this paper, we report the data obtained from the first two sessions that discussed the ideas related to repeating patterns of type AB and ABB. In the first session, the task was based on continuing a given repeating pattern. In the second session, pupils had to complete repeating patterns. Every session included story narration, concept introduction, discussions and worksheets. The teacher acted as the story narrator and also guided the students on their mathematical tasks.

Classroom observations of students' verbal responses, their written work and notes made by the pre-service teacher in her reflective journal (RJ) served as sources of data collection.

Story and the Mathematical Tasks

A summary of the story that was narrated in the class during two sessions follows:

Session 1

On a Sunday morning when Dee and his friends were not able to find a place to play, they requested Dee to help them do so. Dee showed them a beautiful garden through his magic sphere and they accidently entered the garden. None of them was aware that the garden land was ruled by a wicked magician. Dee, Nee and their friends got separated due to the evil spell cast by the wicked magician. He also took away Dee's gadget bag. Now, there were many adventures that Dee had to face in this quest of finding his friends and the gadget bag such as entering the castle where the wicked magician lived. The castle was secured by a 6 layered wired fence which was broken at many places. When Dee tried to enter from the broken spaces, he got a shock. Dee soon realised that the fence had magical powers and that it was strong as long as it was incomplete. Only after completing the fence could one cross it. So Dee had to complete the fence before crossing the boundary to reach the castle gate.

The process of building the fence gave many opportunities to embed tasks on continuing repeating patterns. The children were told that Dee had to complete all the fences given in the worksheet and teacher asked them if they would like to help Dee in doing so. The patterns were given in the form of a worksheet having 9 repeating patterns (Figure 1) of shapes/ symbols to be filled in. The 9 repeating patterns consisted of ABAB-type and ABBABB-type. These were presented to students in a jumbled way. Patterns '1', '3' and '7' were of type AB, patterns, '2', '6' and '8' were of the type ABB. Patterns '4', '5' and '9' were also of the type ABB when their first two units are ignored (such patterns have been categorised by Warren & Cooper (2012) as being of type AAB). Students worked in pairs to continue the patterns.

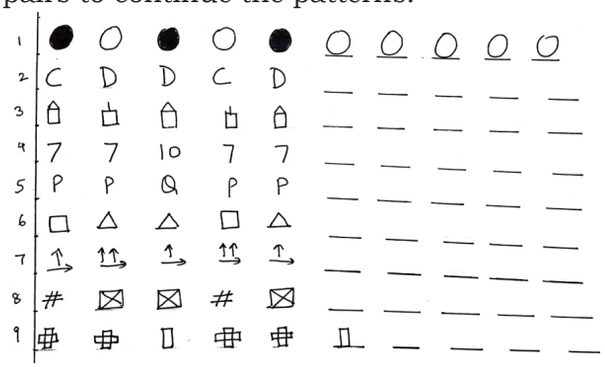

Figure 1: Continuing repeating pattern

Session 2

After the task on continuing patterns was completed, the story continued in the next session.

Having crossed the boundary, Dee had to enter the castle through a huge door .The door was made of huge tiles but Dee saw that there were many broken tiles on it. This time he was careful, he did not try to enter

through the broken tiles. Looking closely he saw, three pieces were missing from each broken tile and many pieces were lying on the floor. He guessed that they had to be placed back correctly in order to complete the door. Only then could Dee enter inside.

In this adventure, the mathematical task given to students was to observe the orientations of the units of the pattern and complete them (Figure 2). In this task, a 'Broken Tile'(Figure 2a) had to be completed using the options 'a', 'b' and 'c'(Figure 2b). Students had to look at the blank space in the Broken Tile and find an appropriate piece that would complete it.

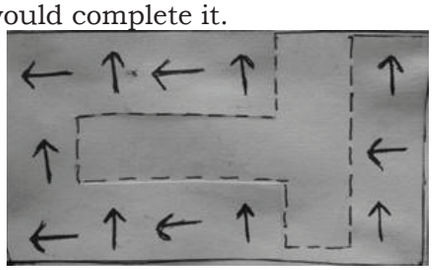

Figure 2a: Broken Tile

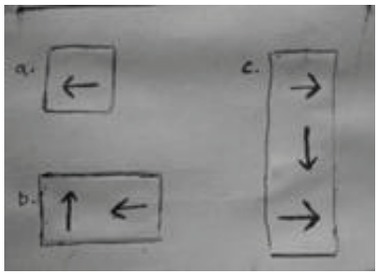

Figure 2b: Pieces

Figure 2: Broken tile completion

Note, while completing the Broken Tile the students had also to consider the orientation of the piece before placing it into the blank space (Figure 3).

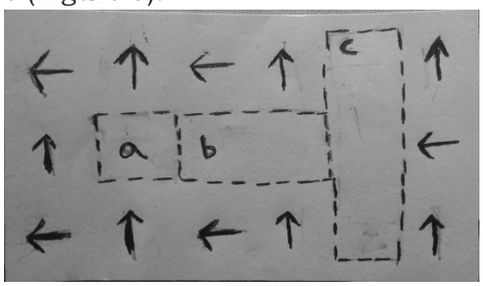

Figure 3: Solution for the broken tile shown

Engagement with the Mathematical Content

In all the story sessions, the teacher ensured that the story gave enough opportunities to the young learners to evolve themselves as active participants in the class. We have shown elsewhere how the specific acts of the teacher constructed a culture of participation (Singh & Gandhi, 2018); in the following sections the focus will be on highlighting students' engagement with the mathematical tasks such as identifying the repeating units and completing the pattern.

Identifying the Repeating Units and Continuing the Pattern

Given below are some examples of children's conversations as they worked on continuing patterns shared as part of Session 1.

For the pattern numbered '1' in Figure 1, some children worded loudly to state the pattern.

> Vidhi: "There is black colour in the first circle, then white colour, then black colour and then white..."
>
> Teacher (to the entire class): "Do you agree with this arrangement?"

Most students replied in affirmation. Then she asked them to state the **colour shape** that could come in the 6th place. Most students said it will remain white. The class proceeded to fill in the circles in alternate colours, black-white, green-orange etc; showing they had correctly identified the AB pattern.

For the pattern '2' (Figure 1), type ABB, some students initially ignored the extra 'D' considering it as the type AB. They completed the remaining blanks as CDCDCD. Seeing this, the teacher asked them to look carefully. A child pointed out the difference.

> Samta: "Here... after C there are two Ds"
>
> Teacher: "So what will come in the first blank"

Sana: "C"

Teacher: "Next?"

Parth: "D"

Teacher: "Next?"

Deepak: "One more D"

Teacher: "You see, there are two D's after each C. So now continue the pattern"

After this familiarisation with a new type of pattern, children seemed more careful in the subsequent questions. For the linear pattern '3' (Figure 1), after some thinking students identified it as being similar to the first question which was of the type AB. So when asked to predict the 6th blank, students responded as "rectangle with a line on it".

A point to be noted in their solutions was that the patterns of the two types were jumbled up in the worksheet yet students could go back and forth between the different types to fill the blanks. They explained the units of repeat as AB and ABB (or AAB) as the case was and filled in the blanks accordingly. They had imbibed the idea of first identifying the unit that was repeating cyclically in the questions and then continuing the pattern.

There was an unexpected response to pattern '5' by one of the students. One student had completed it as follows, 'P P Q R P Q R P Q R ...." When asked about it, the student explained that he had added a slant line under the 'P' at the 4th position and made it 'R'. This way he changed the AAB pattern to a new pattern of type-ABC (ignoring the first 'P' in the process). The child had been able to visualise a new pattern type that had not been intended by the teacher.

Completing the Repeating Patterns in a Planar Surface:

In Session 2, the students had to choose an appropriate piece to fill the Broken Tile (Figure 2a). The task in Figure 2a was an extension of task given in Figure 1 as, while in Session 1 the children had to continue a repeating pattern linearly; in Session 2 the children could consider the pattern in both horizontal and vertical direction. They had to first identify the repeating unit and then choose an appropriate piece to fill the gap. While doing this they had also to be careful about the orientation of the pieces.

After some grappling, children were seen to be checking the orientation of the piece to match it with the gaps. It was observed that children rotated the pieces so as to match them with its correct placement. For example, the piece titled 'a' having a single blank was identified and placed after checking its orientation. But to place pieces 'b' and 'c', the children struggled. Many groups of children asked the teacher for help. They had one common question.

Students: "How to put this piece- this way or that way?"

After some thinking, one of the students from a group announced a method to help everyone.

Aayush: "Aaha...! You can check the pattern along both lines(drawing in air a vertical line and horizontal line) to find the correct pattern".

This remark helped other groups to solve their problems as well. The solution strategy shared by this student was adopted by every group, except one.

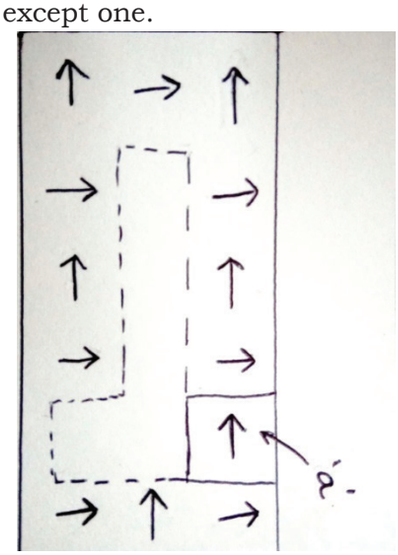

Figure 4: Solution attempted by a group of students

This group proposed a new way. After fixing

the first piece 'a' as shown in Figure 4, they brought the pieces 'b' and 'c' to the teacher and asked her to cut it into three pieces. Teacher did so and the students went back to their seat. Figure 5 shows the cuttings of the pieces 'b' and 'c'.

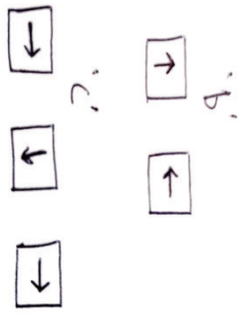

Figure 5: 'b' and 'c' pieces cut into single pieces

Now, they put each piece in its appropriate place by checking each one's position in the line. This method to find solution was invented by the students themselves. Seeing them, many students tore the pieces by hand and placed them accordingly. The teacher wrote in her Reflective Journal, "They have pasted the pieces correctly even if they tore them up in parts....earlier they would not care what they pasted...but today they have put their heads together and their work is very good" (RJ, Session 3, p.24). Children in the class were seen to be inventing strategies to find solutions.

Story as the Backdrop for Motivational and Emotional Engagement

During the first task that is in Session 1 students were spellbound when they were told the story of a famous cartoon character. They looked at the worksheets with wide open eyes as if they were seeing a lot more than the incomplete patterns. There was an element of surprise in their minds about how they could be talking of cartoon characters in their mathematics class. When the teacher asked them to speak about their observations, children were very forthcoming. Students were helping the protagonist by completing the broken fence. They imagined the linear patterns as fences to be crossed by the protagonist. Children were quick to get working on the sheet and they continued the repeating pattern. When they handed back the sheets to the teacher, they asked her to, "Give this to Dee". Since the teacher was the story teller, they expected that just like the teacher communicated the problems of the characters to the students, she would also mediate their solutions back to them. This showed that the children were emotionally attached to the story characters and they considered the problems of the protagonist to be 'real'. In her journal, the pre-service teacher wrote, "I was surprised that they completed the worksheet so fast. These were the same students who did not take the worksheets from me earlier." (RJ, Session 2, p.11). Teacher attributed this change in students' interest to the story. She also added that students were very attentive in the class then. She wrote, "I don't have to tell them to listen to me or remain quiet any more. They are so focussed on the tasks I give them that there are no problems of classroom management" (RJ, Session 2, p. 11) Time had become a resource for the students as they felt responsible for their contribution to tasks. They were eager to finish their task and did not want to waste their time in anything else. They knew any wastage of time on their part could lead to dire consequences for the protagonist. This showed that students were motivated to work upon the tasks embedded in the stories.

During storytelling, when students were told that the protagonist had got a shock on trying to enter the fence, their jaws dropped as if they could feel the shock themselves. Their motivation to complete the fence was fuelled by a desire to help the protagonist. When they completed the task, one child said, "Now the evil magician will get 22 electric shocks, one for each fence completed by us". The teacher later reported that giving 22 shocks to the magician was not a part of the original story, but seeing the enthusiasm of her students she repeated their statement so that it became a part of it. When the teacher announced the 22 shocks that the

evil magician had got due to students' good work, everyone clapped out of joy. This act also shows the emotional connect that students felt with the characters of the story. Their agency to change someone's situation was very powerful now.

When the Session 2 ended, the teacher collected the tiles from the students to arrange them in the form of a door. This was the 'door' that Dee was going to use to enter into the castle. Children's expression showed that they could imagine it to be a real door. The teacher asked the students to check the blocks completed by their friends and everyone did it diligently. She said, "I think they are very critical about their own work. They were also asking friends to check their work. They were checking each and every detail" (RJ, Session 3, p. 23). This was because they had concerns for the protagonist. The class acted as one team working for one goal. The story situation acted as a binding factor for the students. Students were totally engaged in their task because they felt responsible for their acts. They did not leave their seats for anything. They wanted to complete the task allocated to them with precision and alacrity.

Notably, the role of the teacher was only confined to probing the students to think more. She did not provide answers to the students. Her task was to let children get attached to the story characters so that they felt an urge to help the protagonist. She only posed helping questions such as , "Next...?", "So what will come in the blank space...?", "Do you agree to this?"Her limited intervention also encouraged students to find answers themselves with the help of their peers.

Discussion

In the above sections we have provided evidences of students' engagement with the content of repeating patterns that were embedded in a story. We saw that students were able to identify the units of repeat in the repeating patterns given in a linear way and in a planar style. In Session 1, students could identify the units of repeat as being AB or ABB and continued the pattern. They were 'unitising' the reference unit and reinterpreting the situation in context of this unit. In Session 2, it was observed that children rotated the pieces to find the correct orientation of the tiles for completing the patterns. Research suggests that in a repeating pattern spatial orientation is one of the dimensions that students face difficulty with (Tartre, 1990; Warren, Miller & Cooper, 2012) but, students in the story classrooms learnt to observe patterns in two dimensions simultaneously, and, when they could not do so, they found another way to solve their problem, that is, of splitting the pieces into smaller ones.

The students had developed a strong attachment to their work during this time because they felt that their mathematical expertise was valuable for someone in need of help. They felt empowered to drive the outcomes of the story by actively participating in solving the problems faced by the protagonist. Not only did they solve the problems in each session successfully, they also reasoned and extended their thinking, providing valid justifications for their examples. The children were seen to be communicating their insights with their peers. These anecdotes of engagement show that the story not only gave a context to the mathematical ideas but also provided a purpose for students to engage with the content.

The engagement of students with mathematics was evident from their involvement with repeating patterns (cognitive), concern for story characters (emotions) and empowerment to drive the story outcomes (behaviour). Phrased differently, the story helped bridge the gap between their 'subjective and objective realities' (Schiro, 2004). Students' emotional and personal connect (subjective) with the story characters led to their self-initiations and extensions in solving tasks on repeating patterns (objective)- therefore accounting for

the engagement. The classroom had been transformed into an engaged one where participants valued their own knowledge and that of their peers. The story had a role to play in this transition. Stories may have many more potentials that remain unexplored and uncovered.

References

Capraro, M. R. & Capraro, M. M. (2006). Are you really going to read us a story? Learning Geometry through children's literature. *Reading Psychology*. 27, 21-36.

Casey, B., Kersh, J. E., and Young, J. M. (2004). Storytelling Saga: An Effective Medium for Teaching Early Childhood Mathematics. *Early Childhood Research Quarterly,* 19(1), 167-172. Doi: 10.1016/j.ecresq. 2004.01.011.

Courtade, G. R., Lingo, A. S., Karp, K. S., & Whitney, T. (2013). Shared story reading. *Teaching Mathematics to Students with Moderate to severe disabilities*. 45, 34-44.

Egan, K. (1986). *Teaching as storytelling: An alternative approach to teaching and curriculum in the elementary school*. Chicago: University of Chicago Press.

Flevares, M. L. and Schiff, R.J. (2014). Learning mathematics in two dimensions: a review and look ahead at teaching and learning early childhood mathematics with children's literature. *Frontier in Psychology.* 5:459. Doi:10.3389/fpsyg.2014.00459

Fredricks, J. A., Blumenfield, P. C. & Paris, A. H. (2004) School engagement: potential of the concept, state of the evidence, *Review of Educational Research,* 76(1), 59–109.

Lamon, S. (1994). Ratio and proportion: Cognitive foundations in unitizing and norming. In H. Guershon & J. Confrey (Eds). *The development of multiplicative reasoning in the learning of mathematics* (pp 89–121). New York: State University of New York Press.

Liljedahl, P. (2004). Repeating pattern or number pattern: The distinction is blurred. *Focus on Learning Problems in Mathematics. 26*(3), 24–42.

National Council of Educational Research and Training. 2006. *Mathmagic. Textbook for Class II*. New Delhi: NCERT.

National Council of Teachers of Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: NCTM

Papic, M. (2007). Promoting repeating patterns with young children—More than just alternating colours! *Australian Primary Mathematics Classroom. 12*(3), 8–13.

Schiro, S. M. (2004). *Oral storytelling & Teaching Mathematics: Pedagogical and multicultural perspectives*. California: Sage Publications.

Singh, K. P. & Gandhi. H. (2018). *Proceedings of the Seventh international conference to review research in Science, Technology and Mathematics Education*. Mumbai, India: EpiSTEME.

Tartre, L. (1990). Spatial orientation skill and mathematical problem solving. *Journal in Research in Mathematics Education, 21*(2), 216–299.

Warren, E. & Cooper, T. (2006). Using repeating patterns to explore functional thinking. *Australian Primary Mathematics Classroom*, 11(1), 9–14.

Warren, E. Miller, J. & Cooper, T. (2012). Repeating patterns: Strategies to assist young students to generalise the mathematical structure. *Australian Journal of Early Childhood*, 37(3), 111-120.

Wells, G. (1986). The Sense of story. *The Meaning Makers: Children Learning Language and Using Language to Learn*. Portsmouth: Heinemann Educational Books Inc.

Whitin, D. J., & Wilde, S. (1995). *It's the Story that Counts: More Children's Books for Mathematics Learning, K-6*. Portsmouth, NH: Heinemann.