"How many different ways?" -

Computational thinking with Pebble arrangements

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Short abstract

This abstract looks at how by using different types of pebbles, children with visual impairment can understand permutations, which are just different ways things can be arranged or ordered. By playing with pebbles of different shapes and sizes, the kids can learn this concept hands-on. This also helps them in focused thinking, figuring out patterns and solving problems step by step. This fun and interactive approach empowers visually impaired students to explore mathematical concepts with confidence and enthusiasm.

Background

Roman and Catherine Lobo Residential school for Visually Impaired (*Project of SevaBharathi)* was established in the year 2009 to provide formal education to the visually Impaired students acircle the districts of Dakshina Kannada, Udupi region. With the extensive networking, human and managerial resources of SevaBharathi, the school has been able to make significant strides in reaching out to more number of visually impaired children across the region and enabling them to receive the gift of education. Till date around 40 students have cleared their SSLC Examinations and some have even been placed with the reputed banks/ companies from our school and few of them are planning to get a doctorate in their respective fields.

Along with Vision Empower, a not-for-profit organization that works in the area of empowering the education of visually impaired children, we introduced a game-based approach to provide Computational Thinking (CT) in our school since 2021, during the COVID-19 pandemic. Our one-hour a week class to learn CT by playing games has been a big hit among the students who look forward to these sessions.

Computational Thinking, among many other concepts, places importance to learning the skills around counting, grouping, sorting, numerical pattern identification and permutations that are crucial not only for academic purposes but also for practical life. The concept of permutations, that asks the question "In how many different ways can a set of objects be ordered", builds upon basic skills of counting, grouping, and pattern making. In this paper we describe our experience of teaching this

interesting concept with a multi-level game design using pebbles. Through a reflection on our experience, we discuss the various possibilities and challenges in the usage of this game for the purpose of teaching these concepts. We see that even simple games such as these, that use routinely available items, have a lot of power to make concepts like permutations clear to the VI students. We find that repeated playing of the game improves the understanding gradually. We also find that children take varying times to grasp the game and need to be supported accordingly.

Game Design

We designed a multi-level game using pebbles with the objective of teaching the computational thinking about permutations.

Materials required (for all levels):

Object	Description	Count
Pebbles	4 varieties (square, circle, flower, cowrie shell)	For each level, according to the number of objects (n) to be ordered, (n factorial = 1 x 2 X 3 X … X n) number of each variety should be present for use by the student. For example, to create the permutations of three types of objects, six of type 1, six of type 2 and six of type 3 need to be kept ready.
Bowls	To store the unordered pebbles	Two bowls for Level 1, three of Level 2 etc.
Pallanguzhi Board	To arrange the patterns	Optional, can be done on the floor as well
Baseboard with bangles	To arrange the patterns	Optional, can be done on the floor as well

Game Levels

Level	Resources	Description
1	2 varieties of pebbles – 4 of each type 2 small bowls	Squares and circles were used
2	3 varieties of pebbles – 6 of each type 3 small bowls	Squares, circles and cowrie shell were used
3	4 varieties of pebbles – 24 of each type 4 small bowls	Squares, circles, cowrie shell and flowers were used

Preparatory steps

a) Familiarity with all the game resources

Teachers introduced the four different varieties of pebbles to the children for the activity. They provided orientation for the different boards to ensure the children understood how to navigate them effectively. Over several sessions, the facilitators conducted activities focused on identifying, naming, sorting, and counting the same four different kinds of pebbles, fostering the children's engagement and comprehension of the task.

b) Familiarity with the objective of the game - to find in how many different ways can the set of objects be ordered. In other words, how many permutations exists for a set of objects.

Children Profile

The game was played by a group of four children, consisting of Grade 5 and 7 students. Among them, there was one child with low vision, while the remaining three were totally blind.

Findings

In this section, we present our experiences with playing the different levels of this game.

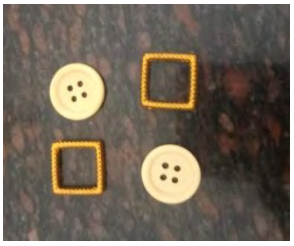
Playing Level 1

The following steps were followed.

- Children were given two types of pebbles, two of each, in a bowl.
- They were asked to identify the number of different pebble types and count how many of each.
- Responses were recorded.
- Children were instructed to take one of each type of pebble and arrange them on the floor in any order they like.
- They were given time to think and arrange.
- Children were asked to verbally state the order of their arrangements.
- Responses were recorded, and assistance was provided if needed.
- Children were tasked with creating a different arrangement using the two pebbles they have left.
- They were given time to think and respond, with assistance available if necessary.
- Children were encouraged to think about any other possible arrangements they can make with the two types of pebbles. Their responses were recorded.
- It was summarized that with two kinds of pebbles, two different arrangements are possible.

With the circle and square objects, the students identified two arrangements as follows:

- Circle, Square
- Square, Circle



During our play, we observed that while few children arranged from left to right (horizontally), a few arranged the objects up and down (vertically). While few children were able to speak about the arrangements they made, few needed help to express it.

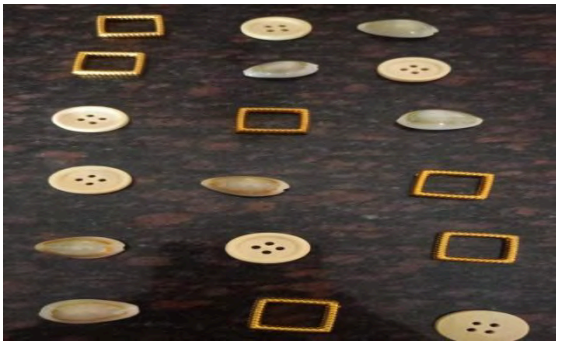
Playing Level 2

The following steps were followed:

- Children were given three types of pebbles, six of each type in the three bowls. 6 of each pebble were given to help children find all 6 possibilities
- The instructions were the same as Level 1 – In how many ways can these three pebbles be ordered.
- Children were tasked with creating a different arrangement every time. After arranging the pebbles in two different ways as instructed, the children were asked to come up with one more unique arrangement.
- Once the children understood how to arrange the pebbles, they were encouraged to explore more possible arrangements.
- Once everyone finished arranging, it was noted that with just three types of pebbles, there could be a total of six different order arrangements.

Square, Circle and Cowrie shell were given which can be arranged as follows,

- square, circle, shell
- square, shell, circle
- circle, square, shell
- circle, shell, square
- shell, circle, square
- shell, square, circle



During our play, we observed the following:

- In the beginning, arranging the different combinations of pebbles proved to be quite challenging for the students, demanding a significant amount of concentration and analytical thinking.
- They required assistance and repeated explanations to grasp the concept fully. However, as they persisted, the students began to comprehend and successfully arrange the pebbles in various combinations.
- To prevent the pebbles from scattering on the floor, bowls were provided to the children. They kept the three bowls in a line and placed the pebbles within them.
- We tried to use a pallanguzhi board that served as a convenient platform for arranging the pebbles. Also a board with bangles pasted to alternate the base board.
- The children brainstormed possible arrangements, often guided by prompts like, "Let's try to find arrangements where a square is in the first position. What options do we have?" This approach simplified the task, leading to more efficient arrangements.
- While some children grasped the concept quickly, others required more practice to master it fully.
- As the number of pebbles given were 6 each it helped children tried to find all the unique arrangements.

Playing Level 3

Difficulty level was increased by asking the students to find the possible arrangements with 4 pebbles. This level was very challenging but interesting as well. The possible arrangements with the square, cowrie, circle and flower were found as follows:

1. Circle, Square, Shell, Flower
2. Circle, Square, Flower, Shell
3. Circle, Shell, Square, Flower
4. Circle, Shell, Flower, Square
5. Circle, Flower, Square, Shell
6. Circle, Flower, Shell, Square

7. Square, Circle, Shell, Flower
8. Square, Circle, Flower, Shell
9. Square, Shell, Circle, Flower
10. Square, Shell, Flower, Circle
11. Square, Flower, Circle, Shell
12. Square, Flower, Shell, Circle
13. Shell, Circle, Square, Flower
14. Shell, Circle, Flower, Square
15. Shell, Square, Circle, Flower
16. Shell, Square, Flower, Circle
17. Shell, Flower, Circle, Square
18. Shell, Flower, Square, Circle
19. Flower, Circle, Square, Shell
20. Flower, Circle, Shell, Square
21. Flower, Square, Circle, Shell
22. Flower, Square, Shell, Circle
23. Flower, Shell, Circle, Square
24. Flower, Shell, Square, Circle

During our play, we observed the following:

- Children tried the possible arrangements and there was a competition on who will find all first.
- Students tried to arrange them mentally at this point. They enjoyed making different arrangement from the pebbles. It was nice to see a shift from concrete to abstract.

As an educator it was very interesting to play this game as this increases the breadth of thinking and students also were very attentive to learn to find out different pebble arrangements. They were learning while having fun.

Discussion

This game using simple objects provides many opportunities for the VI children to learn about permutations. During the session, we guided them with questions like, "In how many arrangements can square pebbles be positioned as the first pebble?", and "What is the count of arrangements where circle pebbles are positioned first?" etc. These prompted the children to think in the right direction.

We found that this activity could be done mentally even without the resources. We tried to do it orally with flower names. We asked, "In how many ways can the names of the flowers – Rose, Lily and Chrysanthemum" be ordered.

1. Rose, Lily, Chrysanthemum
2. Rose, Chrysanthemum, Lily

3. Lily, Chrysanthemum, Rose
4. Lily, Rose, Chrysanthemum
5. Chrysanthemum, Lily, Rose
6. Chrysanthemum, Rose, Lily

In another variation, children were provided with a tactile Sudoku board with number coins. They were tasked with arranging these coins to create patterns.

While the students found it difficult to understand the concept of placing the pebbles in different arrangements in the beginning, it was nice to see after few repeated sessions they were able to make arrangements on their own.

Through these games, the children understood the idea of developing a strategy to solve a problem (First, if I place a square, what can I place next?). This "algorithmic thinking" helps in creating a step-by-step procedure to solve a problem, however complex. The levels 2 and 3, especially, challenge the student to be able to create an ordering and see what can be changed systematically to create the orderings without randomly changing the pebbles all at once. They are required to also employ logical reasoning to decide when to stop the game and decide that all possible permutations are completed. These thinking skills can be facilitated with such simple games even in low-resource contexts.

One key challenge is the increasing number of permutations with every level (2 with 2 pebbles, 6 with 3 pebbles, 24 with 4 pebbles etc.). Placing them on the ground and remembering what was already completed are difficult. We may need to ideate to resolve these issues.

Conclusion

Computational thinking for the visually impaired (VICT) is a very nice project undertaken by Vision Empower. It refers to the thought processes involved in formulating problems and their solutions. Using their approach, we have attempted to develop the skills of pattern recognition, algorithmic thinking, logical reasoning among our students. We see that with simple tactile resources, concepts like permutations can be taught for the VI students. While students may each take their own time to understand and grasp the concepts, playing the game itself is found to be rewarding for them.