Learning Mathematics concepts through Projects and EBD(Education by Design) methodology

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ABSTRACT

Context

We are a team of engineers who run STEM (Science Technology Engineering Mathematics) land – that are rural STEM centres in two outreach schools of Auroville – Udavi School and Isai Ambalam School. Both schools aspire towards holistic development of the child and the managements are progressive. The children attending come from villages surrounding Auroville. Udavi School follows the state board syllabus and we work with ~56 children from 7th to 10th intensively for 6 hrs/week for all their Mathematics (Math) classes. Isai Ambalam School follows the central board syllabus and we work with ~71 children from 3rd to 8th grades intensively for 6 hrs/week during the Environmental Sciences (EVS) and Math classes. In demographics, the occupation of parents in both schools is in unorganized labor e.g. masons, painters, agricultural labor and schemes providing rural employment. The predominant community accessing Udavi School is MBC (Most Backward Caste) and that accessing Isai Ambalam School is SC (Scheduled Caste).

At STEM land children learn Mathematics, Electronics, 3D Printing, Programming (in Scratch, Alice, Geogebra), Mindstorms (Robotics) and play strategic games that enhance logical thinking. The children take responsibility of their learning and plan their goals each week related to their curriculum and beyond it. This self-directed learning is based on Sri Aurobindo's first True principle of education (Aurobindo, 1910); "Nothing can be taught". They create projects that represent their mastery over concepts they learn and can share following constructionism (Papert, 1986). They and work individually, in pairs or peer groups and ask for support from facilitators when they need it. With younger children we work on real life projects that impact their surroundings.

In this paper, we are sharing our experience as practitioners, of how different children learned Mathematical concepts such as sets, algebra, measurements, ratios and percentanges at STEM land. We also look at how technology (both physical e.g. building/construction and virtual e.g. programming) was effective in aiding this process. We will take some case studies.

Case studies

Sets and Algebra: A few children from 10th grade in Udavi School had built a physical game with a chart representing Venn diagrams (where each Venn Circle represented a rule e.g. one for color and one for shape). There were tokens (e.g. red circle) representing characteristics that the player can place and check if it fits in a section of the Venn diagram. The goal is for the player to determine the original rules of the Venn Circles.

This game inspired Diva, a 9th grader the built this game in Scratch. Scratch is a visual programming

language that allows children to build interactive games, animations that are used extensively at STEM land by children to create projects. It requires children to break down a problem into simple enough components so they can be understood by the computer through instructions. We have seen that this helps children learn concepts in a more concrete fashion (Ranganathan s, et al 2015) while improving problem solving, logical reasoning, etc.

In this case, Diva realized that in order for the computer to understand which region of the Venn Diagram was being accessed he needed to divide the Venn diagram (for 2 circles) into A-B (in A and not in B), B-A, A∩B (in A and B), and U-AUB (outside the two circles). Even though visually it looked like a single picture it was in fact composed of 4 different pictures (or sprites). This also helped him understand the different regions of the Venn diagram better. Creating these separate shaped areas allowed him to use sensing of a new object (token) to determine if it belonged to this area or not. He made the game first with a single rule which was not interesting for him to play and he then generalized it so the computer would randomly pick the rules and it would be a challenge for him too. Creating games like these not only help children understand the concepts better, but in testing it add to the rigor of learning the concepts well. Just as Diva had been inspired by a game made by others, 8th graders were inspired by Diva's game to understand how it works and learn about sets even though they did not yet have it in their syllabus. At STEM land we have sessions where children share their projects once a week to encourage such learning.

To be capable of doing the kind of project above children at STEM land like Diva learn scratch by making smaller projects, through peer interactions and through interactions with facilitators. This is generally need based and strong in some areas and weak in others. To make their skills in all areas rigorous we conduct organized courses at STEM land. These courses were based on developing basic understanding of various capabilities of scratch programming to allow children to create more complex code.

After completing one such course a program relating algebraic identities with area was built by a few 8th graders. For example, Jan made a program that drew (a+b+c)2 as three squares i.e. a2,b2,c2, and 2ab, 2bc, 2ca as areas of rectangles. Images such as these were also available in the text book. The images in the book, however, were static and used a fixed value of a, b, c. Then as they changed the values of a, b, c to be variable and random they could see the different sizes still held the fundamental shape of a rectangle to get a sense that these were really variables.

Pond EBD: The second case study is in Isai Ambalam School with real life projects. The children had created a pond (Iyyanarappan a, et al 2019) through which they had learnt measuring length, perimeter and calculating circumference, volume of the pond. While creating mortar they learnt proportions and ratios in order to create the right mixture of sand and cement (3:1). However the pond developed some cracks due to roots from trees nearby. Children came together and built a frame in the shape of the pond and through this they learnt to bend metal rods(6mm and 12mm) at specific angles such as 900 450 etc. They also learnt unit conversion from inches to cm for buying the appropriate rods and to cut them in right dimensions. Once the frame was done, they mixed RCC (ratio 1:2:3; cement: granite gypsum: sand) and poured into the structure filling all the rods and finally smoothened it. Through this process they learnt angles and frames as well as ratios and proportions with more than two quantities. We observed children who are less engaged in academic classes are enthusiastic in building with their hands. In this example we have looked at building technology as a way for children to learn.

Shop EBD: In Isai Ambalam School the 7th and 8th graders had difficulty understanding profit and loss. On looking at the prices of stationary in the shops around they found that the price varied and the local shops in the village were charging too much. They also noted that it was not always easy for the young children to have access to shops for small items they needed like pencils, erasers, scales, notebooks that their parents were not always able to provide at the required time. To move from dependence to interdependence at the school they started a small shop of needful things during recess. They raised the investment for this shop as a cooperative among children and teachers and bought items in bulk from Pondicherry and found that they could provide the same items to the children at a cheaper price than that of any local shops. They started the shop in July and it has been successfully running accounting for all costs including transportation. This stationery shop not only taught the children about profit and loss, but also keeping stock, writing receipts and understanding how shops price materials.

CONCLUSION

Creating projects provides children with a way to demonstrate their learning and offers alternatives to examinations as a form of assessment. Furthe r, it offers an opportunity for self-evaluation and constant progress. Through real life challenges aided by physical technology e.g construction, children can learn a lot even beyond their curriculum and connect theory to practice.

Visual technology like computer can be used for programming and helps children learn conceptual ideas better as they need to break it down into small bites of step-by-step instructions for a computer. Creating visual representation also helps them understand abstract concepts. Learning programming builds rigor as they also repeatedly test their programs.

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