SAIIER Annual Report - Research

Reporting period: 2014–2015

SAIIER supports three kinds of projects: (1) Research, (2) Activities, and (3) Publications & Educational Materials. This form is an outline for reporting on **Research**. Please use as much space as you need for the report.

Please submit this report to SAIIER by **May 8, 2015**. For any questions or clarifications, please send an email to saiier@auroville.org.in with 'Annual report' in the subject line.

1. Title of research project:

Effective curricular integration of technology both physical (BigShotCamera.com) and virtual (Scratch programming) to enhance learning in Math, Science and logical thinking.

2. Brief summary (abstract):

One paragraph describing the aims and objectives of the research project.

The project proposes to address the lack of context in the learning of abstract ideas in Math and Science. Through physical technology such as DIY Bigshot Cameras, Makey Makey, Finch robots and through virtual technology i.e. through programming (in Scratch) in collaboration with other tools.

We also address the question of effective use of computer facilities that exist in institutions by fundamentally changing the nature of the interaction of children with the computer from a user to a programmer. This also allows for children to express themselves creatively and aids their logical thinking skills.

While modeling mathematical problems it also provides children a context for math that they can implement. In addition, it looks at programming as a means to provide an interesting context for children to work on English.

3. Project holder:

Sudhir Pradhan, Sanjeev Ranganathan

4. Report writer:

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5. Research methodology:

What, when, where and who.

Primary work has focused on classroom interventions in mathematics and problem solving in middle school 5^{th}-8^{th} grade. Many abstract concepts are grounded in this age and this was focused on.

This academic year the focus was on extensive use of technology starting with **programming with Scratch** with 7^{h} graders and mapping aspects of Math curricula through projects and challenges in programming. Three broad approaches were adopted for Math curricula through programming:

1) A set challenges for children that involved demonstrating their understanding of abstract concepts visually through programming including fractions, long division, pie charts e.g.

demonstrating what it means to add numerator and numerator and denominator with denominator in a fraction and what is a meaningful way to add it.

2) A set of challenges were based using programming to understand mathematical ideas visually including linear expressions, percentages, simple and compound interest. As an example 5x+10 was graphed as rectangles of varying heights. Then shapes observed by varying the slopes or varying the added constants were observed and interpretations and explanations explored (stair cases of different kinds including making either the slope or constant a random variable, etc). This was then modified to investigate solutions to equations e.g. 5x+10=75 that used the expression and the pictures and paused when the result was reached.
3) Children created games that helped them understand a concept and then work on rigor to master an aspect including positive and negative integers, cube roots that resulted in two digit numbers. Once children get into the mode of creating their own programs often when the computer is available they do not drift and get carried away and play games, they tend to create them. If this is done step by step with values that they put in place first that they knew the answer of and then randomizing it they still want to be able to better their own programs.

Programming was also used in **English** to give life into the stories that the children had created by animating them in scratch. We worked on this project with two grades 7th and 8th.
We had worked rigorously with the 7th graders to use programming to learn math and their results in terms of how elaborate, complex or refined they could make their stories even though they were younger and encountering putting stories to life the first time too was interesting.
The work of the 8th graders at the end of the year was a presentation of 'If I had wings...' a 5 min video developed through over 1000 lines of code and an equivalent play with 60 characters, over 30 changes in backdrop, self-assessment of their own work on quality criteria that was agreed on in the beginning of their work completed in 7-1/2 hrs.

Beyond Mathematics and English, programming was taken further into **sensing the real world** using Makey, Makey. This helped children respond to a real life event like touching a plant, water or items with some moisture content (not complete insulators). Using this the children made their own version of a water tank filling alarm and a non-touch (pressure based) burglar alarm. These exercises helped children connect the programming to sensing the real world and think of applications where they can make use of these aspects in real life. For their final project they built a mat they made from stems of plants that the makey, makey could detect and placed it on an insulator just above the ground. If someone stepped on the mat the mat would touch the floor triggering an alarm.

To complete the loop we also worked on **controlling in the real world** with the Finch robot. This was done by directing the actions of the robot to go around obstacle courses and deliver small paper balls into goal buckets. The most popular game we created was the parking game with a random set of commands that made the robot move around. The goal of a participant was having to predict where the robot needs to be placed initially to reach a fixed goal. We used this version at the school fair which generated much interest.

We also used **physical technology** one being the DIY (Do It Yourself) bigshot cameras that can be assembled by students. Over 50 children from 6 grade onwards assembled the cameras, took pictures and put them on the computer and then used instructions backwards to disassemble them for the next group to use them. The exercise of group work, reading and comprehending instructions and analyzing the pictures was interesting. The hand crank also gave a context to look into gears, ratios. A lot more could be done in optics, imaging. The children were very curious about the 3-D images taken by the camera and experimented with the depth that could be perceived with it.

We received 10 Bigshot cameras from Prof. Sree Nayar of Columbia University, New York. The finch robot and the Makey, Makey by were donated by friends and visitors who felt the impact of technology on learning of children and the interesting mathematics that the children were able to do. Further class notes and work of children is available at (www.smallisbeautiful.blogspot.com).

Since Jan three more electronics engineers have joined us from Aura Auro (a Social science project of SAIIER) and it has triggered a lot of hands on activity by the children including working with motors, electronics and magnetism.

6. Findings:

What are the findings/results of the research project?

Technology can be a powerful tool to explore new pathways of learning in children. However, just as any other tool its usage and the atmosphere created for its effective use is important.

Rural children are able to take to Programming using visual programming languages like Scratch that allows them to stitch the code together (rather than type it and need to compile it). They are also able to advance in its use to make increasingly complex programs in time.

Programming is a significantly different from ready-made computer material for passive learning like online lectures, or animation videos. They are also different from the so-called educational games that attempt to replicate rigor by asking children to solve sums to progress in a game e.g. if given a choice children play games that they are already good at to get a higher score rather than stretch themselves with new games. Playing games on the computer by and large appeals to a child's vital.

However, instead of trying to program the child through the computer, if we let the children program the computer the work moves beyond the vital to mental and beyond. It breaks the socialization pattern of children that the computer is always right and we are always playing catch-up. The children realize that the computer actually needs to be given step-by-step and can't make the simplest connections on its own. It requires children to think for the machine and break down a complex problem into simpler problems. A child is able to make mistakes and learn from them without needing to constantly consult adults and lets them handle their vital impulses of frustration, boredom, etc.

After working on programming for some time, when given a choice of what to do with a computer, more than half the children choose to create or refine something they built than play a computer program they had played before. When the children see a good computer program they appreciate the amount of work that goes into making a computer look smart.

The children learn implicit knowledge e.g. Cartesian system, speed, etc through movements, they learn about agreed conventions and their importance as they increasingly work with each others work.

Children who feel like failures with test scores in time bound examinations, persevere and feel proud when they are able to demonstrate their learning.

The work with physical technology integrates their physical, vital and mental to create concrete objects. It can be as effective as any other technology based on the complexity and dexterity of the object being worked on.

7. Conclusions and recommendations:

How will the findings be used? What will they influence and how? Should the research work be continued?

For effective Math and science education there needs to be context. Technology has become ubiquitous and can no longer be ignored by schools. We need to work on the effective use of technology in providing the context to learn.

We have made a good beginning in the use of technology in Maths. We have been able to map some curricular areas e.g. integers, long division, addition of fractions, linear algebra, etc and implicit knowledge of the catersian system, etc. We have further noticed that children are eager to give life to their stories in English by creating an animation out of it. They are willing to break patterns and get creative and are open to handle complexity.

The research prompts us to take STEM more seriously in our school and we recommend that other schools also look at it seriously. In a few years we may also be in a position to support the training of teachers for those schools that lack the volunteers or teachers to take this up effectively.

The 6th graders worked on the Big Shot camera project for about two weeks to understand gears and measuring voltage. To make this happen, a company donated 10 Big Shot cameras for a pilot project at Udavi. A child received the kit and a manual, with the help of which he or she could identify each component of the equipment and its position in the camera. The children enjoyed the work of assembling the apparatus. They took a number of pictures and picked up several techniques in photography. This has been a very successful project.

8. Products:

What has been created as a result of the research project?

Interest in children in learning science and math.

This particular project covered the uses of a multi meter and a pendulum, and the concepts of speed and motion and voltage. The children also made working models of simple machines, generators and rockets using bottles. Everyone appreciated the special puppet show presented by the students on the theme of the solar system.

9. Knowledge sharing:

How will the conclusions be shared?

We have shared it locally within the school with teachers and students of higher grades. Many of parents came to see the presentation and appreciated the work done by the children. We also shared the same through a couple of blogs.

We hope SAIIER will help us with sharing our knowledge with others.

10. Links and attachments:

Photos, videos, written products, on-line media, etc.

Two blogs are being maintained about the work at Udavi (and Isai ambalam):

1) smallisbeautiful.blogspot.com (by Sanjeev)
2) www.auraauro.com (by Sundar, Bala and Vaidegi from Aura Auro).