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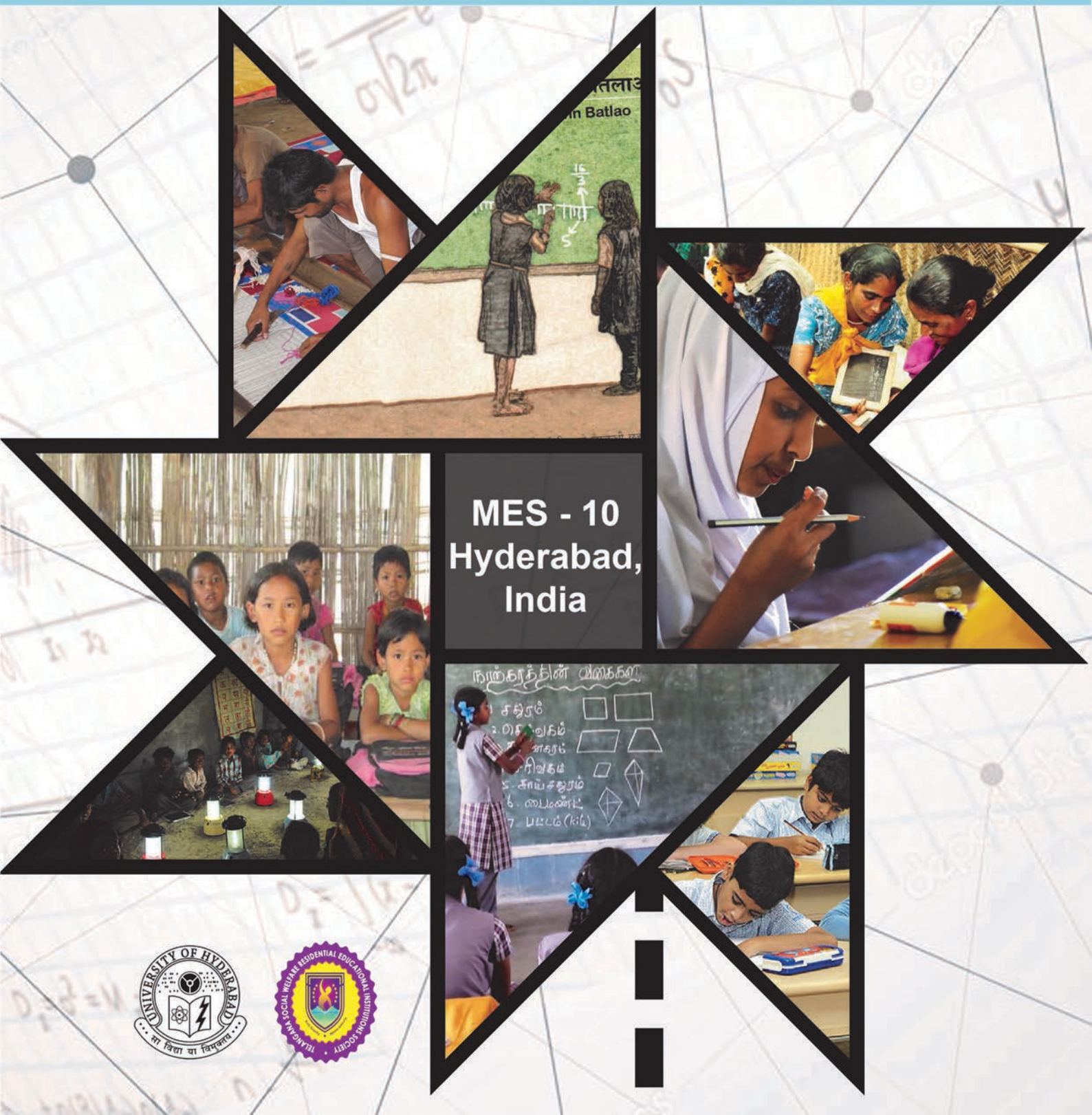

SCIENCE TECHNOLOGY ENGINEERING MATHEMATICS (STEM) LAND: FACTORS AND INTERVENTIONS INFLUENCING CHILDREN'S ATTITUDE TOWARDS MATHEMATICS

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Abstract: *The dislike and fear of Mathematics in children is well documented in literature (Daniel, 1969). Further, literature suggests that children's interest in Mathematics decreases from elementary to high school (Köller, Baumert and Schnabel, 2001). Many practising teachers also tend to believe this. However, a survey with the children in a rural STEM land indicated that their interest in mathematics had been retained or increased from when they were in 5th grade. In this paper, we look at*

1) Is there a co-relation of interest in Mathematics with how well children do in their curricular examinations?

2) We also describe the learning environment and interventions at STEM land and the response of children to these. The questions we focus on:

Will freedom to plan their work help?

Does opportunity to choose working individually or with peers change the learning environment?

Does access to games and puzzles give a broader perspective of Mathematics and will it lead playful learning?

How interested are children in using materials in Mathematics that make abstract ideas concrete?

How interested are children creating projects demonstrate mastery of concepts?

CONTEXT AND INTRODUCTION

This is an Action Research project by a team of engineers who wanted to study our interventions as we implemented them to find out whether these methods and materials would increase children's interest, or exam results, in two rural STEM centres run in two outreach schools of Auroville – Udavi School and Isai Ambalam School. Both schools aspire towards the holistic development of the child and the managements are progressive. The children attending come from villages surrounding Auroville.

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Udavi School follows the Tamil Nadu state board syllabus and we work with 47 children from 7th to 9th intensively for 6 hours/week for all their Mathematics (Math) classes. A few children also come for an activity class in STEM. Other subjects are handled in their regular classrooms. Isai Ambalam School follows the central board syllabus (CBSE) where we work with 48 children from 3rd to 7th grades intensively for 6 hours/week during the Environmental Sciences (EVS) and Math classes. In demographics, the occupation of parents in both schools is unskilled labor (35%), skilled labor (55%) and salaried workers (10%). The predominant community accessing Udavi School is MBC (Most Backward Caste) and accessing Isai Ambalam School is SC (Scheduled Caste). This paper focuses on STEM land at Udavi School and on Mathematics.

At STEM land our goal is to develop the values of responsibility, equality and the courage-to-create in children. At STEM land in Udavi school the children learn to take responsibility for learning and address not only their curriculum, but also create projects that demonstrate their mastery on topics learned (Ranganathan, 2015) and also learn electronics, programming, etc. They do this through self-learning, peer-learning in multi-grade environments and through interactions with facilitators. Children have assessments once in a week on their chosen goals to help them with seeing their progress in addition to their regular examinations from the school. STEM land is also open to anyone to come and learn electronics, programming, Mathematics, puzzles and strategy games. The activities of STEM land that help create a collaborative learning environment are documented in detail elsewhere (Ranganathan, 2018). This paper focuses on specific interventions as listed in the abstract at Udavi.

Motivation of the paper: Change of interest in Mathematics

We asked the children "Rate your interest in Mathematics from the time you were in 5^{th} grade to now". They rated this on a Likert Emberling scale of 1-10 with 1 indicating a strong decrease, 5 a retention and 10 a strong increase in interest.

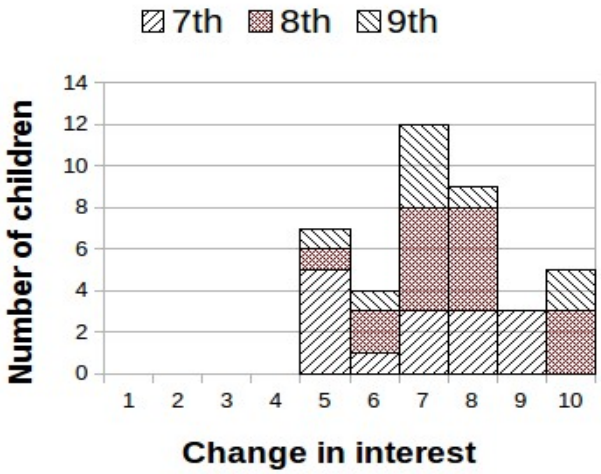

Figure 1: Change in interest in Mathematics from 5^{th} grade for children in 7^{th}, 8^{th} and 9^{th} grade.

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The result of the survey was interesting for us, because it indicated an increase in interest when literature suggests otherwise(Köller, Baumert and Schnabel, 2001). In this paper we look at what could be special about the environment at STEM land that causes interest to increase.

PHILOSOPHIES UNDERLYING STEM LAND

The philosophy underlying the approach for STEM land is based on the principles of progressive and constructivist thinkers like Jerome Bruner in the United States, Sri Aurobindo and Mukunda in India and many others briefly described here.

Constructivist Education Theory (Bruner, 1960) indicates that knowledge is not delivered into the learner (whether child or adult) but recreated by the learner on his or her own. Children actively construct their knowledge by connecting new knowledge to what they already know.

In India, Sri Aurobindo (Aurobindo, 1910) says that nothing can be taught, but the teacher can guide, support and encourage a child in the process of learning, enabling them to evolve towards perfection. More recently, Mukunda (Mukunda, 2009) describes the three aspects of learning that are relevant to schools – conceptual knowledge, procedural knowledge and higher order reasoning. Conceptual knowledge (and change), she states, greatly benefit from constructivist approaches.

Taking a specific aspect of STEM of Maths, the National Curricular Framework (NCF 2005) (Pal, et al., 2005) states that the 'useful' capabilities relating to numeracy, number operations, measurements, decimals and percentages are only a narrow goal of Maths education. The higher purpose of Mathematics, it says, is Mathematization: the understanding and application of Mathematics in different situations with a focus on abstraction, patient problem solving and logical thinking. Meeting this goal requires a fundamental change in the approach used in schools. It requires classrooms to move away from simplistic 'sums' to more complex problem solving and contexts. It requires a shift in conversations in the classroom from the 'right answer' to considering and discovering approaches to problem solving. In a similar fashion NCF treats the development of scientific inquiry as more important than the knowledge of scientific facts.

LITERATURE ON ATTITUDES TOWARDS MATHEMATICS

The role of attitudes in learning Mathematics (Daniel, 1969) has been explored earlier. It has been found that there are many students have a fear of Mathematics, and dislike mathematical activities. Some students completely hate Mathematics, some fear making mistakes. Daniel also suggest that school should be a place where tasks are made more attractive and require educational programs to be more flexible and individualized.

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Conceptualization of academic interest (Köller, Baumert and Schnabel, 2001). This paper says that although interest is usually considered important antecedent to successful academic learning empirical data suggests that this assumption is weak. While doing research in different schools and colleges in different countries the researcher found that interest in Mathematics continues to decrease from Grade 7 onward.

The psychological research and theory of (Silver, 2004) suggests that by having students learn through the experience of solving problems, they can learn both content and thinking strategies. When a problem doesn't have a single correct answer students work in collaborative groups to solve a problem which increases their peer learning. PBL (Problem Based Learning) increases self-directed learning which helps them to solve real life problems. Second, students must be able to set learning goals, identifying what they need to learn more about for the task they are engaged in. Third, they must be able to plan their learning and select appropriate learning strategies. The final goal of PBL is to help students become intrinsically motivated by their own interests, challenges, or sense of satisfaction.

CORRELATION WITH CURRICULAR EXAMINATIONS:

Here are the results and analysis of some of the surveys conducted with 45 children in STEM land. 7th Graders had experienced STEM Land for six months, 8th graders for one and half years and 9th graders for two and half years. Ten STEM land facilitators conducted the survey. The survey of 14 questions was on their experience of various interventions of STEM land. The survey was conducted in a one-on-one interview with children (in English and Tamil as requested by the child). The researchers, who are also the teachers conducted this survey.

Linking with the original research of how children view mathematics (Daniel, 1969) we asked:

How is Mathematics different from other subjects?

In each class from 7th to 9th grade, there were about 15 to 16 students. In every class around 65% of the children said that Mathematics is difficult compared to other subjects. Among the children who found it difficult some found numbers and calculations confusing, others found it difficult to remember formulas. One child even said that Mathematics is the most difficult subject among all the subjects. 25% of the children said that they are able to notice that they use math in other subjects and said that it helps in life. Very few children said that there is no difference between Mathematics and other subjects. Only 8% of them said that they are interested in Mathematics and it is easy to understand. Some children even distinguished Mathematics as a subject from what they do at STEM land.

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Correlation between interest and curricular examinations

Using the data on change of interest in Mathematics for each child from 7th to 9th grade and we calculated the Pearson Correlation Coefficient (PCC) with how well they did in their curricular examinations. We found that for 7th standard the PCC was -0.4329 which means the answer they gave for the interest level and the marks they have scored in exam was inversely related. For 8th standard the PCC was 0.222142 which is positive but very weak. For 9th standard the PCC was 0.171023 which was also weak. Similar to what we see in literature (Köller, 2001) we do not find a strong correlation between how children do well in examinations and their interest in Mathematics in the limited sample (47 children) in STEM land.

INTERVENTIONS AT STEM LAND AND OBSERVATIONS:

We focus on a few specific interventions and the response of children to these here.

Intervention: The freedom given to plan their work

At STEM land, we believe children are responsible for their learning and for their growth. A software was created at STEM land to support children create a plan and track their progress. Children create a plan of what they are going to learn each week. They are assessed each week on the goals they work towards and children can track their progress visually as a pie chart.

Response

We asked "*How satisfied do you generally feel at the end of a week? On a scale of 1-10 with 10 being fully satisfied and 1 being not satisfied*". This question was asked to understand how students were responsible for their learning. Figure 2 shows that almost all the children are satisfied on working towards their goals.

We also asked what they did when goals were not met. Most said that they work harder and seek support from peers and facilitators. Some children said that they work at home to complete what they set out to do. Only a few mentioned that they felt sad and were not able to proceed to the next topic.

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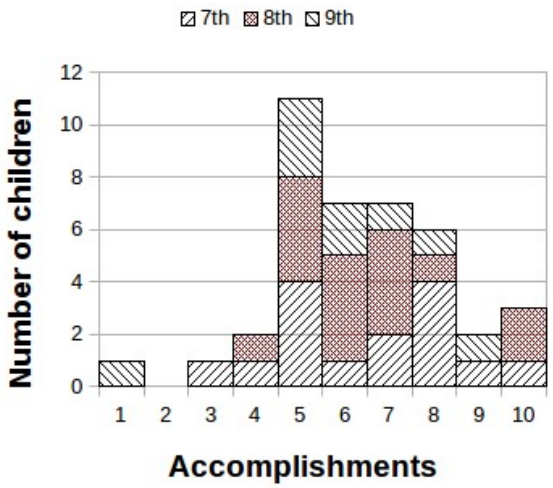

Figure 2: How accomplished children generally feel at the end of the week

Intervention: Access to games and puzzles that give a broader perspective of Mathematics and are joyful

At STEM land we have an active environment of challenging ourselves with many puzzles and strategy games. The puzzles include physical disentanglement puzzles, rubiks cubes, etc. The games include strategy games such as Abalone, Othello, etc. These are as often checked out and used by children (even if it is for a short time) as laptops. There is a fairly large group of children who can solve the rubiks cube.

Response

We asked children "*How stressed or joyful do you feel at STEM land (1=stressed, 5=neutral and 10=joyful)?"*. We found that most of the children felt joyful being at STEM land.

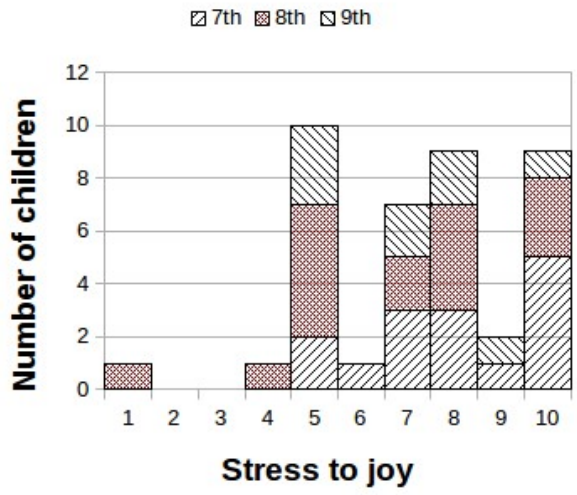

Figure 3: How Joyful children feel working at STEM land (1=stressed, 5=neutral and 10=joyful).

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We also asked "*Where and how do you use math in your day-to-day life?*" Children furnished numerous examples about how they use mathematical concepts in real-life: some mentioned that they use it while shopping and to calculate monthly expenses for their house.

One child said that he uses Mathematics to change his perspective, when he had only

10 minutes to complete a task he changes this into 600 seconds and this helps him calm down and complete his work. He said this had increased his confidence level.

Intervention: Choice of working individually or with peers

At STEM land children have a choice of working individually or in groups. This allows for individual learning as well as peer-to-peer learning. In addition, in a week there are four to five multi-grade classes. Where younger children and elder children work together and collaborate in learning.

Response

The response to a question of "How often do you collaborate on a scale of 1 to 10 (1-rarely, 5-often, 10- always)" is shown below. This indicates that most of the children often collaborate with others, working in groups and sharing what they have learned.

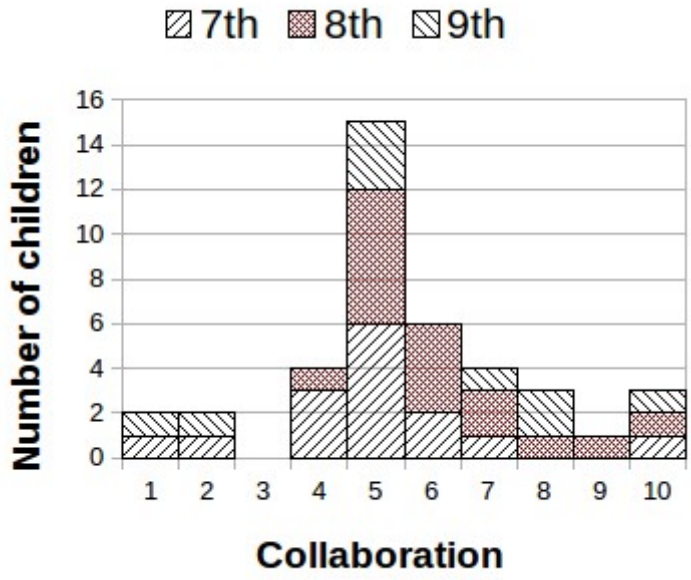

Figure 4: How often do I work with other children (1 – rarely, 5 – often, 10 – always).

When children were asked to list what they learned from peers they said they learned to solve problems that they don't know; Math concepts like square root, factorization; strategy games like Othello, Abalon; to solve the Rubiks cube; programming in Scratch, Geogebra and Alice; mind-storms (robotics), and electronics like makey makey, soldering. Some children also mentioned that they learned how to effectively use STEM land including using laptops, checking-in and out materials,

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filling plans for the week, taking up responsibilities for specific materials at STEM land and even not being afraid and asking for help when you don't know something.

Intervention: Access and use of materials in Mathematics to make abstract ideas concrete

In STEM land children have access to a wide variety of materials that make mathematical concepts concrete including Montessori, Jodo Gyan, etc.

Response

We asked children "*What is your interest in learning mathematical concepts using materials in STEM Land on a scale of 1 to 10. 1 being not interested, 5 being interested and 10 being very interested"*. The average score was close to 8.5 and none of the children in all three grades went below a score of 5 on using materials.

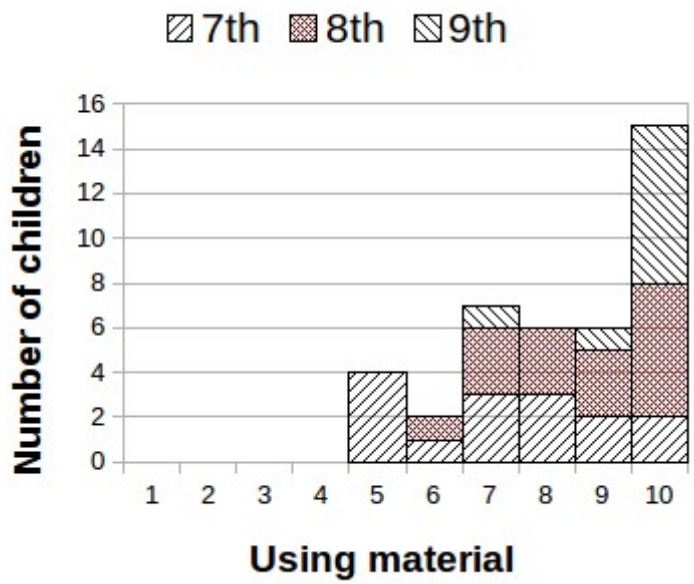

Figure 5: Interest is using materials to learn mathematical concepts.

Intervention: Creating projects that demonstrate their mastery of concepts

In STEM land children are encouraged to create projects while learning mathematical concepts. This is done by the facilitators themselves creating projects, allowing children to work across grades. Children take their own idea to create a project that they learned in their chapter. Projects can be both physical e.g. creating a sets game or in software e.g. creating a visualization of a concept or an interactive project or game.

Response

We asked children "*How interested are you in creating projects on a scale of 1 to 10 (1 not interested and10 very interested)*". Most children said they like learning through projects. Children mentioned that when they make projects they get clarity

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on the concept. Some mentioned that they are able to solve problems easily after making a project. They are able to learn new things like programming while doing a project.

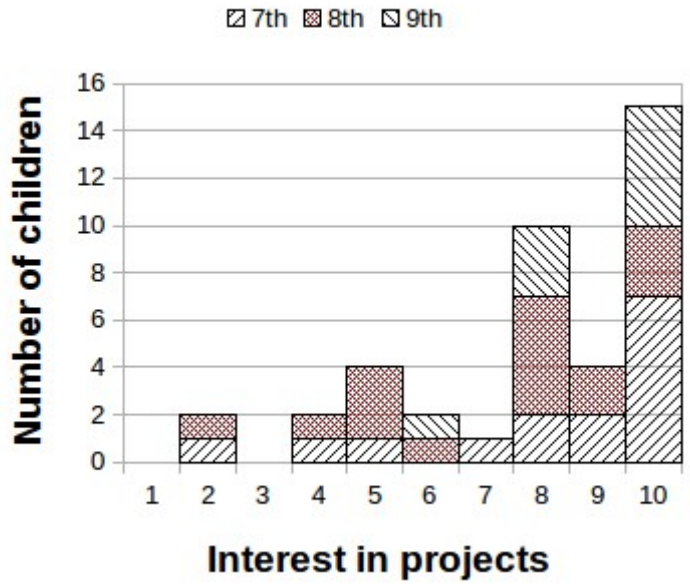

Figure 6: Interest in making projects (1-not interested, 5 – interested, 10- very interested).

Some children mentioned that while doing a project they face many problems and they are able to break down big problem into smaller problem. While working on a project children are able to think about how to proceed step by step. Having completed the project, if they forget the concept, they are able to revisit their project they themselves made to remember that concept.

CONCLUSIONS

Children have retained or increased their interest in Mathematics when they come to

STEM land.

Their interest is inversely or only weakly related to their ability to do well in curricular examinations. This implies that even those who do poorly find something of interest at STEM land.

We examine various interventions and their responses

the freedom to plan their work – gives them a sense creating a plan and accomplishment.

choice of working individually or with peers – allows them to work as they most effectively can.

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access to games and puzzles that give a broader perspective of Mathematics and are joyful – makes it fun being in STEM land.

access and use of materials in Mathematics to make abstract ideas concrete –

helps make mathematics more accessible.

creating projects that demonstrate their mastery of concepts – helps them express their creativity.

We continue to explore various interventions that alter children's attitude towards Mathematics.

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REFERENCES

Aurobindo. Sri. (1910) The Human Mind, *Karmayogin*.

Bruner, J.S. (1960), The Process of Education, *Harvard University Press.*

Daniel C. N, (1969) The role of attitudes in learning mathematics, *National Council of Teachers of Mathematics.*

Goos, Merrilyn (2004) Learning Mathematics in a Classroom Community of Inquiry, 55 *Journal for Research in Mathematics Education.*

Köller.O, Baumert.J and Schnabel.K (2001) Does Interest Matter? The Relationship between Academic Interest and Achievement in Mathematics, *National Council of Teachers of Mathematics*

Laurie A. F, et al., (1994), Gender, mathematics performance, and mathematics-related attitudes and affect: *A meta-analytic synthesis, International Journal of Educational Research 21* (4):373-385.

Mukunda, K.V. (2009) What Did You Ask at School Today, *Harper Collins*.

Pal.Y et al., (2005) National Curricular Framework, National Council of Educational Research and Training [pdf]. Retrieved from http://www.ncert.nic.in/rightside/links/nc_framework.html

Ranganathan.S, Anand.B, Kodanaraman.S, Gunasekar.V (2015) Using programming with rural children For Learning to think mathematically, *epiSTEME 6, HBCSE.*

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Ranganathan.S, Iyyanarappan.A, Anand.B, Kumar.N, Patchaiyappan.P, Ganesan.P, Kodanaraman.S, et al., (2018) Fostering responsibility in learning in rural schools, *epiSTEME 7 HBCSE*

Silver. C.E.H, (2004) Problem-Based Learning: What and How Do Students Learn?, *Educational Psychology Review, Vol. 16, No. 3*

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