Altered traits of alumni from a collaborative learning environment

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Abstract: A rural STEAM centre aims at developing responsibility in children, the courage to create projects and the competency to work together in this collaborative learning environment. Here children have freedom and responsibility to plan what they work on, develop mastery in Mathematics through projects in electronics and programming, work individually or with peers, etc. These factors appear to support develop a positive attitude towards Mathematics in children at the centre. This paper is based on reflections of alumni two years after graduating from the centre. What factors do they still appreciate? We examine both the skills and attitudes they developed, retain and apply in their further education and life. What are the altered traits alumni retain when they transition from such centres to mainstream education?

Context and Introduction.

C3STREAM Land (C3 is *C*onscious for Self, *C*onscious for Others, *C*onscious for Environment, STREAM= STEAM+ R (Research), henceforth referred to as C3SL) are rural STEAM centres in Tamil Nadu in India. This paper follows the alumni of the centre at Udavi school, one of the outreach schools of Auroville. Auroville is a universal township that works towards human unity and engages with the villages around Auroville. Most of the children attending the school come from Edayanchavadi village.

Udavi school aspires towards the holistic development of the child and follows the Tamil Nadu state board syllabus. C3SL works with 80 children from 6th to 10th intensively for 5 hrs/week for all their Mathematics classes at Udavi. The STREAM

centres have been in operation in the school for the last 5 years. In demographics, the occupation of parents of the children is unskilled labour (35%), skilled labour (55%) and salaried workers (10%).

The aim of the C3SL centres is to develop the qualities of responsibility, equality and the courage to create alternatives. At C3SL centres the children learn to take responsibility of their learning and have freedom to plan and set their goals each week. They can choose to work individually, with peers across grades in multi-grade environments or with facilitators. They have access to Mathematics materials, strategy games, puzzles that help them engage with mathematics and play games. They have access to computers where they program in Scratch, Geogebra and Alice and also 3D modelling and printing. They also have access to electronics, Makey-Makey, robotics and other materials interacting with engineers who work in the industry. These help children not only address their curriculum, but also create projects that demonstrate their mastery on topics learned. The use of programming to develop mathematical thinking at C3SL has been documented before (Ranganathan, 2015, pp.339-346).

In India the lack of interest in education is attributed as the number one reason for children to drop out of high school (Government of India, 2018, pp.126). Among the subjects Mathematics is considered the most difficult subject requiring special attention not just in India, but across the world. While both literature (Köller, Baumert and Schnabel, 2001, pp.448-470) mainstream teacher experiences suggests that the interest in Mathematics deteriorates as children get to higher grades at C3SL there was an improvement in attitude towards Mathematics in children from 7th to 9th grade from when they were in 5th grade. We examined the factors based on the interventions mentioned above earlier (Ganesan, 2019, pp.894-898) when children were part of C3SL and had access to it.

In this paper we look at the following research questions:

1) How alumni reflect now on the factors attributed to the improved attitude of children towards Mathematics when they were at C3SL. Specifically:
   - the responsibility and freedom given to plan their own work
   - creating projects physically and with programming on mathematics, electronics, robotics, etc.
   - choice to work alone or with peers
2) If alumni found their experience at C3SL useful and what skills they learnt that they have applied in higher education.
3) Given the diversity of what they experienced, other factors they valued at C3SL.
4) If the experience at C3SL resulted in *altered traits* in alumni in determining their choices in higher education and how they perceive they would like to learn.

Altered traits are defined as a new practice or attitude that endures beyond the environment that helped create it (Goleman & Davidson, 2017, pp.8)

Philosophies underlying C3SL

The philosophy underlying the approach for C3SL 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.

The theoretical framework of the work at C3SL is based on the three principles of true education by Sri Aurobindo (Aurobindo, 1921, pp.1-8):

- Nothing can be taught
- The mind needs to be consulted in its own growth
- From near to far

The first principle can be linked to the constructivist theory that knowledge cannot be forced into the mind of a child, nor can a child be moulded or hammered into the form desired by the adult. That the teacher can guide, support and encourage a child in the process of learning, enabling them to evolve towards perfection.

It further indicates that each human being is in their own path of discovery and progress. This is also recognized in the National Education Policy (Government of India, 2020, pp.12) which states that 'knowledge is a deep-seated treasure and education helps in its manifestation as the perfection which is already within an individual.' We would like to examine how the children have continued their journey and what role, if any, C3SL had in it.

The second principle indicates that the child needs to be consulted in his/her learning. This is done at C3SL as the children to plan what they want to work on (choosing a plan to work on) and how they want to work on it (self-work, peer-work, creating projects, etc). The children have this freedom and responsibility and we examine what the alumni felt about this.

The third principle is to work from near to far. To work from what is tangible and accessible to children to what is abstract to them. The children work on projects they care about, materials they can access and manipulate and move towards abstract ideas. They also create projects and programs at C3SL that take abstract ideas in Mathematics and convert them into visual projects that make them concrete.

Constructivist Education Theory (Bruner, 1960) is in line with the philosophy 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.

Contemporary thought is also aligned with these ideas, 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. Procedural learning benefits from learning to program a computer to do the procedure. Higher order skills benefit from problem solving methodology.

While earlier curricular frameworks in India had already suggested shift from 'useful' capabilities to understanding and application the NEP 2020 states clearly:

> 'Pedagogy must evolve to make education more experiential, holistic, integrated, inquiry-driven, discovery-oriented, learner-centred, discussion-based, flexible, and, of course, enjoyable.'

In the context of the nation-wide conversations captured by the NEP the interventions being carried out at C3SL of creating experiential, learner-centred and enjoyable collaborative learning environment that challenges children to show their mastery by creating projects is relevant. Equally important is how these interventions are perceived - noticed, appreciated and retained by the children themselves over time.

Methodology of the research

Selection of Alumni
We use purposive sampling focusing on one batch of alumni of C3SL at Udavi School who had been at the centre in their 8th and 9th grades and were now in other schools in their 12th grade. This batch was selected because we were looking for a sample of students who have been away from C3SL for at least 2 years and had also experienced it for at least 2 years. The alumni are following the streams of humanities (arts), commerce and science with a predominant number in commerce.

This is a qualitative case study and the data collection consisted of
a.   A group sharing of the nine (of thirteen) alumni on what they are doing and what they have retained and used from their experience at C3SL.
b.   This was followed by a review of the intention of each of the 20 questions of the survey.
c.   The children then filled out the survey individually.
d.   Four children who could not attend the group sharing filled out the survey remotely without (a or b).
The primary data collection for this research was 'c' and 'd' and 'a' was the secondary data collection used for cross verification.

The survey was created with the intention of having both a qualitative (Linkert scale) question linked to a descriptive one that would clarify the choice with details and reflections. The selected Alumni were in 12th grade and it was expected that they would be able to respond to these questions in simple English in writing. We felt that this would give them the time to reflect and respond rather than take interviews with us.
The survey had both broad questions like usefulness of C3SL in their life, or their memories of C3SL, as well as pointed questions on specific interventions of C3SL. We expected the descriptive questions to bring out the diversity of responses of how they engaged in with C3SL in line with the specific teachers experience of the children's engagement at C3SL. We also included questions to verify if indeed their current environments were different from what they experienced at C3SL, how they coped with the change and what they preferred and more importantly why.

The conversation and the responses were analysed to understand what the children have found special, useful and what continues to be useful and impacts them about C3SL. The descriptive responses allowed us to check for factual consistency with their teachers and our records e.g. of what children they had created in C3SL. While we focus on the three interventions all the questions and responses of the survey is available online (C3SL, 2020) for review. The children know C3SL by its former name STEM Land and this is the name used in the raw data for children. We, however, continue to use C3SL to retain the flow of this paper.

Survey and Responses

We had noted factors or interventions that had improved the children's attitude towards Mathematics when they were at C3SL. We reviewed these with the alumni to see if they still found these interventions significant.

Intervention: The freedom given to plan their work

At C3SL, we believe children are responsible for their learning and for their growth. Children create a plan of what they are going to learn each week. They are assessed each week on the goals they work towards.

To understand whether children prefer to plan what they want to study or prefer that the teachers plan for them we asked two questions, '*Do you get the freedom to choose what you want to learn in the school you are in now?*' and if the response was negative '*Would you prefer to work with freedom of choosing what you want to learn or not?*'

Except two students all of them said that they don't have the freedom to choose what they want to learn in the schools they study now and all of the students said they prefer to work with freedom of choosing what they want to learn. One of the children specifically said that he wants to have his freedom to choose what he wants to study, but he can't because of society since the importance is given to marks rather than knowledge.

We have also asked children '*What are the difficulties you face switching from the system we follow in C3SL to other school environment?*' Children said that they perceived the system in C3SL as having the freedom to choose what they want to do, access to resources needed and being allowed to interact with everyone. This made C3SL a joyful environment. They felt not having such an environment limits learning as they are not allowed to use resources even though they are there, nor find support when needed. They have also said that they had to memorize everything, had to always study and don't have any other activities. One child remarked 'By choosing to learn I dedicate more in learning.' [By choosing to learn I am more dedicated in learning].

Intervention: Creating projects physically and with programming on mathematics, electronics, robotics, etc.

In C3SL children are encouraged to create projects to demonstrate their mastery of mathematical concepts. Children learn programming early through peer learning and

with facilitators. Children come up with their own idea on projects based on what they learned in their chapter these could be physical projects e.g. building a game or in software e.g. creating a visualization of a concept or an interactive project or game.

We asked '*Did doing projects in Scratch, Geogebra and Alice help you in any way?*' All of them said doing projects using Scratch, Geogebra and Alice helped them to remember the concepts in Mathematics. All the children said that doing projects helped them in many ways such as to improve their speed in Mathematics and is easy to understand Mathematical concepts. One of the students said that doing a project in Scratch helped her to learn graph, and computer programming. One of the children said that Scratch helped him get a different perspective, Geogebra to learn geometry. They still remembered the projects they made and owned their work. In response to their current status all the children said that they don't get the resources, time and support from staff in the school they are currently attending for such activities. One of the children said that she feels more comfortable working with computers when compared to the other children in the school she is currently pursuing.

We asked them about projects not directly linked to academics that some of them worked on '*Were you able to learn mathematics concepts when you work on electronics, robotics and Big-shot? 1 – less, 5 – neutral, 10 – more.*' All the children were positive or neutral about this and in the descriptive responses four of them said they were able to learn mathematical concepts while working on electronics, robotics and Big-shot cameras.

Intervention: Choice of working individually or with peers

At C3SL 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 some multi-grade classes which allows children to work across grades. At C3SL the children learn about themselves and how they like to learn in response to the question, *'How useful was peer learning?'* one of them indicated that they liked to work alone, another was neutral about it the rest preferred to work with peers.

Further we asked children '*Do you continue to learn with peers in the other schools?*' Most of the children have said within the classroom they can't continue peer learning as they don't have an environment where they can communicate with other students or share freely with teachers.

In response to '*Have you taught anything you learnt from STEM land to your friends in other schools?*' Almost all children indicated that they had taught something to others they mentioned using Ubuntu, programming in Scratch and Alice, html, practical geometry, solving the Rubik's cube. Further, in response to an earlier question on application of what they had learned children shared that they are helping their friends and classmates understand concepts through alternative methods and taught puzzles and Rubik's cube to others.

Usefulness of C3SL

We asked the children to rate and answer '*Was C3SL useful for you (on a scale of 1 to 10) and if so in what way? 1 – Not Useful, 5 – Useful and 10 – Very Useful.*'

Figure 1 indicates all students felt that C3SL was useful for them. In the descriptive response thirteen children indicated that C3SL helped them learn programming and Mathematics through Scratch, Alice, puzzles and games. One child reflected that he used to look for answers to the questions, but his experience at C3SL has helped him look instead at the methods of solving a question. One child said that it is useful for his higher studies specially in Mathematics and Physics. Another said it is useful for him to learn animations and electronics. Yet another said it is useful to learn new things. Each child brought forward a different facet of C3SL based on their own interest and what they explored at C3SL indicating that each found something he or she had explored based on the diversity and freedom given to them.
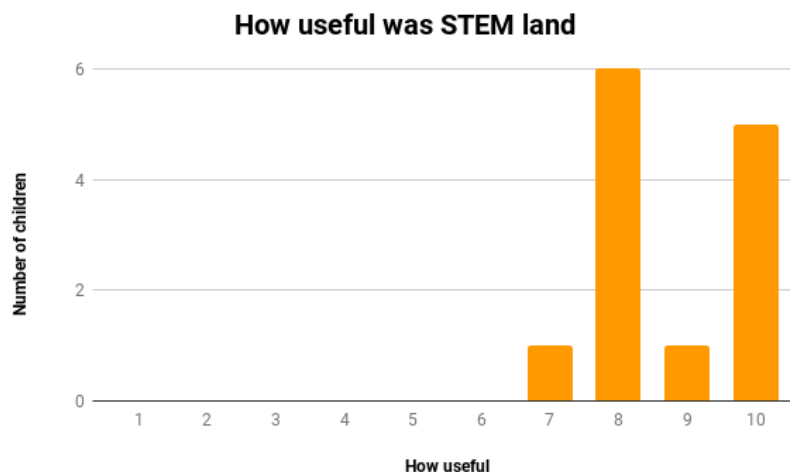

Figure 1: Rating of '*Was C3SL useful for you (on a scale of 1 to 10)?*'

What they retained and its application in higher education

We asked a question '*How much are you able to retain what you have learnt in C3SL? (1 - Not Retain, 5 – Retain, 10 – Retain Very Well)*'. Most children felt they were able to retain concepts they learned in Mathematics as well as what they learned in programming through Scratch, Geogebra, Alice, Goanimate as well as working on hardware such as Arduino, Mindstorms, Makey Makey which are programming related or Mathematics related.

To the question, '*How much (of this) are you able to apply in your higher studies?*' the children wrote that they felt that they found Mathematics related subjects such as Accounts, Economics as well as Computer Science related subjects Computer Application and Computer Science easy due to the similarity with what they learned in C3SL. Children also mentioned that they are helping their friends/classmates in understanding concepts through alternative methods in which they had expertise. One of the children mentioned that he learned lots of shortcuts in Mathematics and is able

to apply them in his higher studies. In the conversation before the written survey one child even mentioned that she was among the only two girls in a class of fifteen in a Computer Science and she was topping the class.

We also asked a question '*What course are you pursuing?*'. Most of the children who have graduated from C3SL have opted for Mathematics related fields such as Commerce, Science, Computer Science and Biology with Mathematics. One student who took humanities (Arts) took up Computer Science as an elective.

'*How are you doing in Mathematics as compared with other subjects? 1-10.*' Out of thirteen students seven of them said they are doing well in Mathematics as compared to other subjects. Two students mentioned that Mathematics helped them to score more marks in other subjects like Accounts and Physics. The remaining students did not have Mathematics as a specific subject in their course. Others indicated that they did not have Mathematics but Computer Science they do well in.

Interventions noticed by children

We looked across the questions on aspects noticed by children about the environment created at C3SL and how they felt there. In a response to '*One thing you feel proud of being in C3SL*' a child wrote 'freedom, relationship, learning, understanding among student and staff'. In response to the transition to mainstream schooling a child wrote 'we enjoyed the environment in C3SL but now we are totally away from happiness.' On the response to the question *'Did playing games help you learn Mathematics?'* the children had mixed responses to whether playing games helped in Mathematics as such, however, one child wrote, 'yes! that made time to relax my mind', similarly in response to '*How interested were you in solving the weekly puzzles? 1-10*' while most children said they were not interested again we had a different child write, 'I felt my mind get relaxed and very interested.' The diversity provided at C3SL for differing tastes of children allowed each child to find something they enjoyed illustrated in '*Share your memories of STEM land.*'

> 'I loved playing games and getting the freedom to choose what I want to learn. I very much enjoyed the (leadership) workshops. Because I learnt a lot about myself and my class mates.'

The children were sharing about the leadership/stewardship workshops we had offered children to make choices from their possibility (universal values they care about) rather than socialized fear. Another shared, 'I liked Stewardship that gone (was held) weekly once with our team staff. I enjoyed it and I am still following my stand and fear.'

The diversity of what touched the children in C3SL '*One thing you feel proud of being in C3SL*' four students said that learning programming and being able to create projects made them feel proud at STEM land. Two students mentioned that soldering and electronics kits made them feel proud of STEM land. Three students have said that they feel proud of being a STEM land student. They have also mentioned that STEM land gave the additional knowledge apart from text books and that they feel proud of the

teaching method being part of a buddy system, having freedom to choose what they want to study, exposure to games and logical puzzles. One child captured the environment as 'freedom, relationship, learning, understanding among student(s) and staff(s)'.

Conclusions

Improvement of interest in Mathematics with grade is an important goal of Mathematics education across the world. The interest of children in Mathematics had improved in children at C3SL due to the interventions such as:

- the responsibility and freedom given to plan their own work
- creating projects physically and with programming on mathematics, electronics, robotics, etc.
- choice to work alone or with peers

while children were in C3SL. This research found that alumni even after two years after they graduated from C3SL and no longer experiencing such an environment perceived these interventions as formative to their understanding of how they like to learn, that it made it environment joyful and made them responsible.

All of them felt that they would like to continue plan their own work as they did at C3SL and choose how they want to engage with others. Even through most were not allowed to engage with peers within their classrooms now, they were supporting peers and had taught something they had mastered at C3SL to others beyond classrooms.

Each of them brought forward a different facet of C3SL they engaged with some in response to specific questions on projects, programming, electronics, games and puzzles and some as a response to generic questions about their experience e.g. leadership. A few of them specifically brought up the leadership and how it continues to play a role in their lives allow them to work from possibilities (universal values they care about) and transcending socialized fear.

We observed that the children had retained skills not only in Mathematics, but also in Programming, Electronics, etc. Further they had developed a positive attitude towards these and most had taken up Programming in their higher education even if they had chosen Arts as their discipline of choice across gender.

The children not only understood what they had learned, but also had clarity in the development of logical thinking, strategies and multiple methodologies of solving questions. They also shared that they found the learning environment joyful.

We see that interventions at C3SL had not only short-term effects on improving attitude of children towards Mathematics, but also longer-term impacts in their attitude towards how they understand themselves and how they learn. We term these as altered traits, indicating the impact of the few years they engaged in C3SL continues to have in their lives moving from one 'among the crowd' to 'standing out of the crowd'.

We believe these interventions if introduced as part of Mathematics classrooms could support children taking responsibility for their learning as well as create supportive environments for their peers. This is relevant not only in the National Education Policy 2020 for India, but also for children across the world to use Mathematics and STREAM not only as skill development, but of developing responsibility both towards themselves and others.

Acknowledgements

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