

THE POSSIBLE MISSING INGREDIENTS IN ENGINEERING HIGHER EDUCATION –MASTERING SELF, AGENCY TO SHIFT DISEMPOWERING NORMS AND SOCIALIZATION AND MASTERING TECHNICAL SKILLS

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Engineering higher education in India, especially rural India, does little to help youth learn about the universal values they stand for or develop their inner capacity, or develop agency to address disempowering socializations, it does not even prepare youth with practical industry ready skills. What possible missing ingredients when put in place would prepare youth for an effective and meaningful life for themselves and others? This paper is an autoethnography of five youth who are completing a one-year residential program called “Being and Becoming a Shifu (Master)”. We present how the program added these missing components in helping us connect with universal values, develop system thinking and five minds of the future, confidence in skills, being independent and interdependent and self-assessment.

RESEARCH QUESTIONS

The one year *Becoming and Being a Shifu (Master)* (BnBShifu) program helped us youth understand what we care about, increased self-awareness, self-regulation, responsibility, and develop confidence technical skills of VLSI (Very Large Scale Integration) layout and programming. It helped us notice our own socialization, develop system thinking. This helped develop the five minds of the future - disciplined mind, ethical mind, respectful mind, synthesizing mind and creative mind. We reflect on 'how this happened', or perhaps, how this could happen in Higher Education (HE) with practices at BnBShifu and its impact on us:

- 1) How did the program encourage youth to connect to their universal values (universal values apply for everyone, everywhere such as dignity, equity, courage)?
- 2) How did the program support develop system thinking, noticing patterns and five minds of the future?
- 3) How did the program build confidence in skills and in competence to move from being dependent to independent to interdependent?
- 4) How did the program provide timely feedback and build the ability of self-assessment?

We refer to *universal values* as those that can be embodied by everyone, everywhere irrespective of their caste, culture, gender, age, etc such as dignity, equity, courage. These form the basis of sustainable and equitable change for a thriving people and planet (Monica, 2017). As Monica states:

When we source universal values, and express them through strategic action, multitudes of initiatives come alive, and a vast array of ideas find expression based on our aspirations, interests, and talents. Our independence is wholesome through our

interdependence.

We distinguish these from the common uses of the word values in different contexts such as - something important; or a socialized culture (of a specific group, caste, or religion e.g. how women/men should dress); or in business as money added at a stage in a value chain; or as operating principles (e.g. excellence in academia, privacy in online transactions) which varies with context.

HIGHER EDUCATION IN INDIA: CHALLENGES & OPPORTUNITIES

The quality of the HE institutions and colleges in India is not on par with other countries like China, Singapore (Singh, 2011). Singh states that some of the institutions are run as a profitable business where the rural and semi urban pupils are trapped. In our country 68 percent of the country's universities and 90 percent of colleges are "Middle or poor quality". He recommends institutional sharing between high quality institutions and these to take them to the next level. (Sheikh, 2017) suggests an alternative paradigm of new-age online learning tools to address various challenges of Indian higher education and to bring equity. Contemporary research (Manya, 2020) indicates that the Indian Education system is concentrated more on the marks rather than giving importance to the skill that has been built. Specifically, the unemployment in Engineering graduates is due to a lack of skill and competence (Tilak, 2021). Tilak shares that technology is transforming the labour market across the world 80 percent of Indian engineers are not fit for any of these jobs. India needs to interlink academia and industry.

To improve learning outcomes in HE (Harackiewicz & Priniski, 2017) suggests targeted interventions in how students value their tasks, how they engage with their academic work and their communication with their professors. Across domains students who framed their academic challenges and could self-reflect were more motivated and had better outcomes. Other solutions are linked to the need for feedback in

improving the learning experience for the students in HE (Bashir, Kabir, & Rahman, 2016). That providing quality information to students about their learning and feedback to the students develops the ability of students in self-assessment.

Further there is a question of what HE should inculcate. (Ronald, 1990) argues the hidden understanding of HE beyond economics is the need to develop physiological and sociological perspective in students. Ronald highlights certain points that can be included in HE like self-reflection, open learning, group activities, interdisciplinary learning that can lead to developing these aspects.

We feel that the five minds of the future (Gardner, 2005) synthesize what is needed by youth - the disciplined mind (understanding, application and memory) for skills, the respectful mind (dignity for all), the ethical mind (human unity) caring for people and planet, the synthesizing mind (ability to notice patterns) and shift unhealthy socialization and creative mind for new solutions from care as distinguished from innovation which is only a function of the mind.

In this paper, we will look at how the BnBShifu program which offered no marks or certification developed our skill, competence and inner capacity. It started with connecting us to our potential or inner values and developing technical skills needed in the industry embracing the solutions suggested in literature including feedback from mentors, self-assessment, setting targets, peer learning, using rich online resources.

RESEARCH METHODOLOGY

The primary research methodology is autoethnography based on reflections of five youth (represented as ShifuX: Shifu1, Shifu2, etc) who are completing the BnBShifu program. We feel that a methodology based on reflection is appropriate as we are addressing the lack of the reflection in youth and in our education system. We hope multiple reflections mitigate the weakness of autoethnography of not to being general enough. The gaps in HE described in literature is

our lived experience as engineering graduates in rural India. We hope what was useful for us in BnBShifu will be useful for further interventions at scale.

Based on general reflections on the program we came up with questions that we felt might give a framework for us to synthesize our experience making it relevant for a broader audience. We then recorded our reflections for these questions. Given the limited length of the paper we have been selective in sharing insights and may have cut them short with ‘...’ in the hope to bring a new point. We have also dropped a question regarding how the program helped us develop healthy living which we felt was important to share with youth, but we realize many aspects were possible due to the residential nature of the course and may not be scalable. We will make all responses including those of a couple of new joiners (3 months) of the BnBShifu program available online after the review process (Arulselvam, Anandavelu, et.al, 2022).

BACKGROUND OF PARTICIPANTS OF BNBSHIFU PROGRAM

Sharing our background before we joined the BnBShifu program may aid understanding our reflections. We all studied engineering in colleges in villages around tier-II/III cities as shown in Table 1.

Who	Age	Course	M/F	College Location	Work-ex
<i>Shifu1</i>	23	B.Tech. EEE	M	Ariyur, Puducherry	0
<i>Shifu2</i>	23	B.Tech. ECE	F	Serumavilangai, Karaikal	8 months
<i>Shifu3</i>	24	B.Tech. ECE	F	Serumavilangai, Karaikal	0
<i>Shifu4</i>	24	B.E. EEE	M	Chellankuppam, Cuddalore	1 year
<i>Shifu5</i>	24	B.E. ECE	M	Mailam, Villupuram	9 months

Table 1: Background of participants of the BnBShifu program (and authors of this paper).

Shifu1: In my college they focused only on marks and I memorized to clear all papers and not get arrears. I could tell the memorized definitions, but had no in depth to explain further. Sometimes I even forgot the definitions as I had not understood them. Even in practical exams I memorized the circuit connection by using a manual. When asked, the lab staff did not offer us an explanation of how things worked as they felt it was not needed to pass the examination.

Shifu2: ...I thought scoring high marks will help me to get a job in the tech industry. After college, I got a job as a data entry operator. There was no progress in my learning except achieving targets. There I didn't get time to take care of my health or engage in any other activities.

REFLECTIONS TO DESCRIBE THE BNBSHIFU PROGRAM

Shifu4: When I first heard about the program, I thought that it will be like other usual courses of training in programming, but it was totally different from my imagination.

The application form itself was completely different from anything I had ever seen. It asked about personal *information* (e.g. biodata), personal *knowledge* (e.g. if I prefer to work early in the mornings or late at night) and personal *wisdom* about self-analysis, self-awareness, self-regulation, responsibility. Especially the wisdom section where they asked for universal value, cultural shift, responsibility, and healthy habits was a different experience for me and made me think.

We started the day with Surya Namaskar, running and Anapana meditation. We then had team meetings often with RTL (Radical transformation leadership) training sessions (Monica, 2017) and then we concentrated on learning skills and then I practiced to make myself perfect. We interacted with each other and with our mentors to learn and also had sports or gym in the evening, at times we watched TED

talk and reflected on it and the day was completed with book reading and daily reflection.

The RTL program helped me to find what I stand for and be one with my universal value; the program offers tools, templates and distinctions that connect real-life experiences and help me see problems from my universal values and come up with solutions that are in line with them and the shift I want to see in the world. It helped me address my bias and socialized fears and gave me a path to overcome them...

Shifu1: In this program I learned I stand for kindness and equity for myself and others. I committed to spending a year in the Shifu program as an input from my side. The output of the program was that I learned VLSI layout, programming in Scratch, Python & SKILL, Radical Transformation Leadership (RTL), Spoken English, Maths class, Book reading session, and Vipassana (VRI, 2010)... I learned to meditate and notice myself. I also changed my food pattern to a healthier diet and avoid snacking... I joined the program for technical knowledge, but here, I also learned useful life skills and RTL tools. The program also gave me time and space to think about the purpose of my life...to notice that only earning is not going to fulfill my life so I learned to serve and help others. I started teaching children (in my last semester) what I know, while teaching, I noticed that I'm also learning from them.

Shifu3: ...Here the first one or two weeks it felt that we were doing so many things like learning technical skills, sport, meditation, and following ground rules...But, as I settled in, I learned time management and created time for everything to have an enriching day, each day...We also had access to STEM land a space with games and puzzles created for children where I went to learn and refresh myself. Every week we visited some places in Auroville and met new people who they shared how they are serving the community and what they care about and I was inspired to be courageous and independent like them. Once a week we also presented what we learned to others.

Everyone in the program had taken up accountability like managing the kitchen, finance, maintenance, and so on this made me more responsible and accountable.

An important point that came up in all reflections was developing good habits of being disciplined about eating times, and being healthy mentally and physically.

REFLECTIONS ON THE RESEARCH QUESTIONS

1) How did the program encourage youth to connect to their universal values?*

Shifu1: All of us have universal values within us, but we do not notice them or not act from them. This program had RTL which helped me think about my universal values I really care about for myself and others. Whenever I share an insight, I start by sharing my universal values. I stand for equity and kindness for myself and for others. When I keep on telling my universal values they became automatic I acted though equity and kindness. The words allow me to connect to what I deeply care about, but I'm not stuck to the words and understand their essence is to make me better. I believe RTL tools, templates and distinctions can also support youth to connect to their universal values.

Shifu2: I learned who I am being when I am at my best i.e. the universal values I hold within. I noticed that what I admire in others are qualities I want to develop within me. After discovering my universal values, I started to work from them. It made me think differently of how I can handle situations. I started to notice situations when I was not in my universal values and reflect and shift my mindset. The impact and outcome of practicing some RTL tools is it made me notice my own bias towards genderism and my own background conversations.

Shifu3: This program helps me become more self-aware and I discovered the inner values I stand for equality and happiness, through RTL. I used tools in RTL to overcome my fear and work

courageously. It also made me aware of what I am doing in every situation and I learnt how to process experiences and learn from them. I started to design my projects using CFSR. I can breakdown the problem and what are the actions I can do differently to progress. I learned to be responsible.

Shifu4: ...It starts with the searching what a person deeply cares about and makes him/her understand their stand... It helped me change my mentality from caring only for 'me, myself and I' to caring for 'myself and others'. In addition, the Shifu program supported my problem-solving ability even technically and gave me confidence in facing the problems instead of getting into fears...We had ten days of Vipassana meditation which helped me to come out of my cravings and accept the reality to move forward. It helped to develop a concentrated mind.

Shifu5: The complete awareness of my values and for what I stand for came after attending RTL workshop...Here the values have important essence of connection for goodwill, strength and supportiveness for everyone universally.

2) How did the program support develop system thinking, noticing patterns and five minds of the future?

Shifu5: The Disciplined mind: ...The program gave me the time stay with topic till I understood, applied and remembered it. I found this way of learning to be an investment for my life and it stood as a north star for my life as a programmer and being human.

The Respectful mind: Here the learning was without hierarchy. Learning from each other and supporting others to learn emphasized respect for everyone...

The Ethical mind: Vipassana meditation helped me be moral and dignified and supported put the RTL tools in practice not only being moral, ethical, but also integral (whole)...

The Synthesizing mind: ...I used to memorize information, but synthesising helped me retain and look for patterns and use learning in other contexts. This included learning programming and problem

solving in code-wars, reflections at the end of the day, processing a TED talk or a workshop.

The Creative mind: There are no ready-made answers to important challenges and I learned to be creative and adapt. There can be one good answer, but I learned to look for alternative possibilities that emphasis goodwill...

Shifu2: ...After I learned the basics, I completed a task in that domain. After completing several tasks, I worked to synthesize the new ideas that I learned. Then I connected new learning with what I already knew. This helped me to learn new domains easily... When I heard presentations from others summarizing what they had learned and I needed to present my own learning I learned to synthesize.

Shifu3: ...Initially, I wondered why with VLSI specialization I was learning programming, but as we went along I realized that I had developed my logical thinking, problem solving and automation that I applied to my specialization. I applied logical thinking in the electronics lab and the process of taking small tasks and going in depth and completing it helped me learn something new that I can use to work efficiently in the next task.

3) How did the program build confidence in skills and in competence to move from being dependent to independent to interdependent?

Shifu1: When I was new to this program, we experienced doing experiments in an electronics lab... I never had this kind of exposure in my college to do individual work...

Shifu2: Initially, I was dependent on my mentor to learn new techniques and skills in VLSI layout, then I was given tasks. As I completed tasks, I felt more confident to work independently. I noticed it took more time to complete tasks alone as compared to when I had peers who I could talk to. Sharing of new learning and discussing with peers made me feel interdependent and more efficient. This built my confidence and faith in working as a team.

Shifu5: Before joining BnBShifu I thought I'm not the type to learn programming. In the program a personal mentor guided me based on my capability. I was introduced to learning at my own pace online using the Coursera platform that had many courses that were project based. Every time I made a project, I felt more confident. When I got stuck, I got the support of my mentor who would ask me questions rather than just give answers. After that I was introduced to code-wars a website for challenges in coding at various levels. Here, I needed to pick my challenge and I started to understand where my level was and could see how I was able to take up challenges at higher levels as I got better in programming. I became independent and could assess what I was capable of. Relating what I do with my values and in resonance with the five minds of the future gave me interdependence.

4) How did the program built the ability of self-assessment as well as provide timely feedback?

Shifu1: In this program we had an opportunity to record our insights - reflections about what I learned and about how I feel here in our daily reflections. Our mentors read and interacted with us and this helped to clear our doubts in the same day itself...

Shifu2: Getting the input and feedback from my mentors, helped me to level up my state of progress. In technical skills, mentors supported me and gave feedback that helped me notice my gaps. In time, I started noticing my own gaps and this self-assessment had a major role in my progress and learning e.g. noticing how much time I took, what ideas from a previous tasks I could have used to complete this task.

Shifu3: In college I just got marks and neither got feedback from my teachers nor did I find where I made mistakes to correct myself. But in the BnBShifu program mentors supported me by giving feedback for growth (increase, decrease, retain) to improve myself helping me identify where I was and progress swiftly.

Shifu5: I feel self-assessment of looking at patterns of how I did things

and how I can make it better is the best way of assessment and helps get many creative answers. This gave me courage to neither give up if I don't get the answer nor stop with a single answer...

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Conclusions

We the youth describe the missing ingredients of our education system were experienced in BnBShifu program. Here we built our leadership skills through RTL training that helped us learn what universal values we deeply cared about and want to manifest in the world building our respectful, ethical and creative mind. We developed our disciplined mind with the support of challenge-based online courses like Coursera and platforms like code-wars and practiced self-learning, peer learning, presentations, feedback and got guidance from mentors (practitioners). We developed our synthesizing mind with daily reflections, using RTL tools to process experiences and presenting what we learned technically to peers. We had access to practitioner mentors who asked us questions rather than give answers and gave feedback that helped us notice gaps and build self-assessment. As we built projects we moved from dependence, to independence to interdependence in creating a learning community with peers. There were no specific teachers, professors, no marks or certificates and yet we learned and found meaningful employment. We work in the areas of VLSI layout, software design and design automation while putting aside time to support others learn what we know as others who invested in us through the BnBShifu program. The third area design automation is a combination of the first two and was created as the program progressed.

We feel responsible to question status quo in the norms of our education system and to showcase what needs to be added to make the education system whole. We hope these ideas from this program will be scaled to benefit rural youth like us in India.

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Notes:

CONSCIOUS TEACHER TRAINING: SUPPORTING INNER DEVELOPMENT ALONG WITH DEVELOPING SKILLS AND COMPETENCIES

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The purpose of education is beyond fitting in (getting a job, being a good citizen) and standing out (having a successful career, being a critical thinker) it should allow children to simultaneously know themselves and embody values, notice patterns they want to shift in society and solve problems. What would be the qualities of the teacher, facilitator who can guide the students to be such leaders?

How can a technical teacher training program, in this case study, a course on the use of programming to learn Mathematics for teachers (educators), be designed to support these qualities in teachers? When such a design is implemented does it achieve its purpose of addressing not just skills (programming, solve problems), but competencies (how to use skills to change culture or shift systems), and inner capacities (working from

embodying values)?

CONTEXT AND INTRODUCTION

Auroville is a universal township with a goal of realizing true human unity. Auroville belongs to humanity as a whole and works on physical and spiritual researchers required to achieve its goal.

STEM (Science Technology Engineering Mathematics) land – runs rural STEM centres in two outreach schools of Auroville – Udavi School and Isai Ambalam School. The children attending both Udavi and Isai Ambalam schools come from villages surrounding Auroville. The schools of Auroville and STEM land work on the philosophy of Integral Education based on the principles of Sri Aurobindo and the Mother.

Integral Education looks at holistic development of a child; developing and perfecting the physical, mental, vital (psychological, emotional) natures of a child to allow them to express their inner being in the world (Neeltje, 2001). This will not only benefit themselves (independent/individualistic), but also the world (interdependent/collective). Such an education addresses the purpose of education beyond fitting in and standing out.

The environment most suited for Integral Education is one where the child progressively learns about himself/

herself and can make choices on their own. This environment is broadly referred to as ‘**Free Progress**’ system, where children are provided freedom make progress towards learning and understanding themselves deeply. At a practical level this appears as freedom with responsibility in learning. While the responsibility of learning rests with the child, it is the teacher/facilitator who has a big role in creating a meaningful learning environment and this role is far larger than that of a traditional didactic teacher. How this philosophy can be implemented is one of the challenges and the research carried out at Auroville Schools.

At STEM land in Udavi school 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 (Ranganathan, et.al., 2017) 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, 1921); “*Nothing can be taught*”. The children create projects that represent their mastery over concepts they learn and can share following constructionism (Papert, 1986). They work individually, in pairs or peer groups and ask for support from facilitators when they need it. At STEM land at Isai Ambalam school we work with younger children work on tangible real-life projects that impact their surroundings and school addressing Mathematics and EVS (Iyyanarappan, et.al., 2019).

Scaling: How can such a program be scaled to different contexts; different levels of skills of facilitators and varying availability of resources was one of the questions that drove this research. We felt that scaling what was special about STEM land was not the access to materials or skilled staff, but the environment of taking responsibility of one’s learning. Creating an

environment where children can use freedom responsibly was not easy and required teachers or facilitators to have the courage to step beyond their socializations and create an environment that worked for the children and themselves. The goal was to avoid prescriptive top-down (or bottom up approach) to one that was inside-out with the teachers manifest what they care about deeply in their workspaces while being equipped with STEM skills.

This is an action research, the paper reflects on the design and implementation of a teacher training program that builds capacity through skills, competencies and inner capacities.

PRINCIPLES UNDERLINING THIS WORK

The focus of the paper is teachers/facilitators and their training. In this regard the principles of true education by Sri Aurobindo (Aurobindo, 1921). indicates that *‘The teacher is not an instructor or taskmaster, he/she is a helper and a guide. His/Her business is to suggest and not to impose.’*

The NCF 2005 (Pal, et al., 2005) also states *‘teacher plays a role of a facilitator, supports and encourages learning, involves active participation of learners, develops multidisciplinary curriculum, focuses on education, brings about multiple and divergent exposure, multifarious, continuous appraisal in educational system’* these are very high goals for which teacher’s initiative and leadership is important.

Making projects (through programming) is a way for children to demonstrate their learning and offers an

alternative to examinations for assessment. Projects also offers an opportunity for self-evaluation and constant progress. Programming a computer helps children learn conceptual ideas as they need to break it down into small bites for a computer to follow. It also helps them visualize abstract concepts. They can also create their own games to develop rigor. Work on programming and learning Mathematics that has been carried out at STEM land and documented before and not repeated here (Ranganathan, et.al, 2015) is the basis of this course.

This 8-day program designed in line with capacity development to address sustainable and holistic results through a conscious full spectrum response (CFSR) (Monica, 2017, p. 236) as shown in Figure 1. A CSFR based capacity development simultaneously addresses.

1. immediate causes that requires technical solutions through skills
2. systems and cultural causes that require system and cultural transformation through competencies
3. underlying factors that require embodying values and being a transformational leader through inner capacities.

The figure also conveys the definitions of skills, competencies and inner capacities.

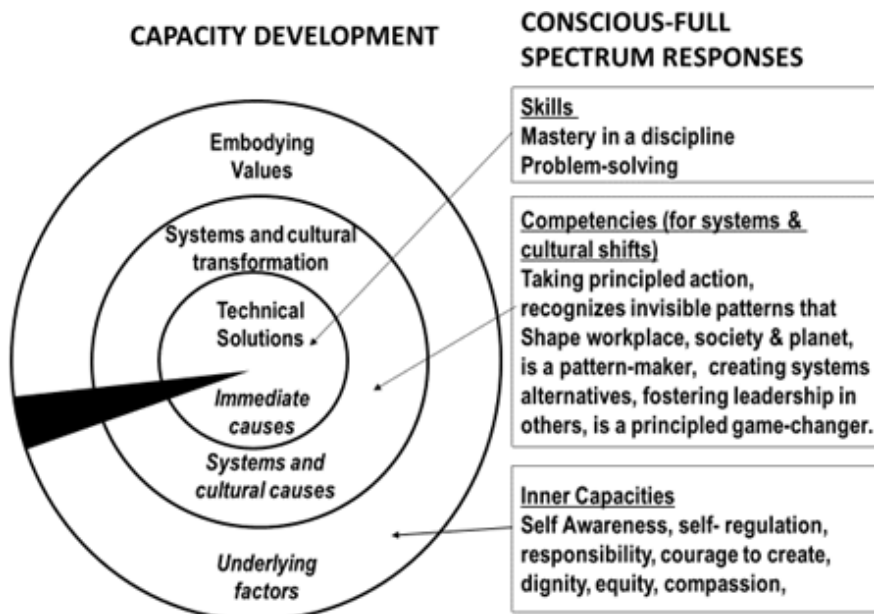


Figure 1: Capacity Development for sustainable results at scale.

DESIGN OF TEACHER TRAINING PROGRAM

In line with the principles above the target outcomes of this training program was:

Skills

Creation of projects through programming was one of the core skill areas of the program where teachers

themselves learned creating projects to addressing challenges.

Basic & Intermediate (for Mastery)

- Scratch Programming – Interactive queries (sensing), drawing different shapes (pen), animated stories (events, looks), maze game, blocks or functions in scratch, concentric circles with perimeters(variables), and mathematical concepts, pen (shapes, mandalas), fractions, coordinate geometry, graphs.
- Geogebra: Introduction, drawing shapes, midpoint, ratio of perimeter of circle to different polygons that fit in a circle.
- Using hardware for programming : Makey-Makey.

Expert (for exposure and for those who were already at intermediate level before the course)

- Scratch Programming - number line (integers subtraction), algebraic identities, square and cube roots (of large numbers), vernier callipers (explanation), nuclear fission (animation).
- Using hardware with Programming - Scratch: Finch robots, mindstorms, interactive camera, Snap for Arduino.
- Geogebra : Solar system, mandala, clock, interactive inputs, animation.
- Programming with Alice 3D - Introduction to a 3-D world, setting up a scene and props, customizing characters and animation.

Competencies

- Ability to listen deeply, reducing judgements and biases.
- To notice my own socialisation and not be limited by it.
- Recognize the invisible, multiple patterns and systems that shape societal and planetary situations and actions; recognize interdependence.
- Design and deliver on actions through CFSR, simultaneously in real time (1) source wisdom (2) shift systems and (3) solve problems.

- Enrolling partners through responsible speaking.
- Looking for commitment for action behind complaints.

Inner Capacity

- *Self-awareness*: What I stand for and my socialized fears. Courage is not the absence of fear, but my ability to transcend my socialized fears and act from my stand.
- *Self-regulation*:
 - o Distinguish one's wisdom (stand) from social, professional and personality identities (or profiles).
Embrace all with respect for diversity (using wisdom profile).
 - o Noticing my Background conversation (based on socializations) and still myself for listening deeply to a person (or a child).
- *Courage to create*: Creative solutions with CFSR.
- *Responsibility*: Integrity lens noticing my wholeness in being my word, looking for alignment in my work and my values - speak up and speak out, being the change, I wish to see - *embodying values*.

The participants of the training program were from Auroville, Pondicherry, Chennai, Gujarat, Mumbai and

Sittlingi. Most worked with NGOs working with marginalized communities including slum children, tribal children and rural children studying in government schools. The background of the participants was also diverse from teachers working on supplemental computer sessions to school management. One of the goals was to train people from around Auroville to allow them to start STEM centres in their own organizations. Each day of the workshop addressed each of the areas of skills, competencies and inner capacities and the plan for a typical day is shown below:

Day 2 - 03/05/19	
9.30 - 9.50	Sharing insight (what I learned about myself yesterday)
9.50 - 11.00	Noticing my Background conversation (based on socializations) and still myself for listening deeply to a person (or a child)
11.00 - 11.10	Thought Break – Walk, stop, clap, name
11.10 - 12.30	Scratch Programming continued: Drawing Shapes or Mandalas or Pythagoras theorem (depending on their plan)
12.30 - 1.30	Lunch
1.30 to 1.40	Inspirational videos: Isai Ambalam Video (10 min)
1.40 - 2.45	Scratch Programming continued: Projects on fractions/pie chart.
2.45 - 3.00	Break
3.00 - 4.25	Advanced Scratch Programming: Mindstorm using Scratch 3
4.25 - 4.30	Daily Reflection + Quotation of the day
Take home activity	1. Draw a mandala or any shapes using pen in Scratch 3 2. Using variables and random number show multiplication

Table 1

METHODOLOGY OF THE RESEARCH

The data for the research collected from the software program created for the course to track the progress of the participants. The software

captured:

- a) Survey data collected from feedback for the course at the end of the workshop. In the survey the participants conveyed what they felt they learned through the course under skills, competencies and inner capacities.
- b) Daily learning and self-evaluation entered by participants that was used to record the learning each day as well as a repository of projects made by them to verify skills learned.
- c) Insights shared in plenary each day as unlike skills, competencies and inner capacities expressed by participants are subjective and harder to verify. However, insights gave a sense of these and some are reported here.
- d) Few notes based on communication/interaction with participants on what they have implemented after the workshop.

RESULTS

Skills

The survey on the skills (Fig 2) indicate that most participants felt that they had mastered many of the basic and intermediate programming outcomes.

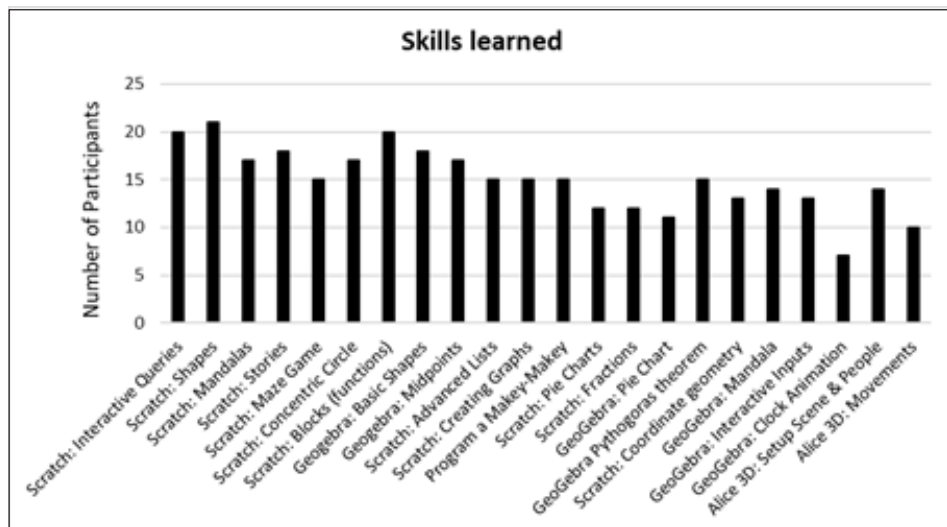
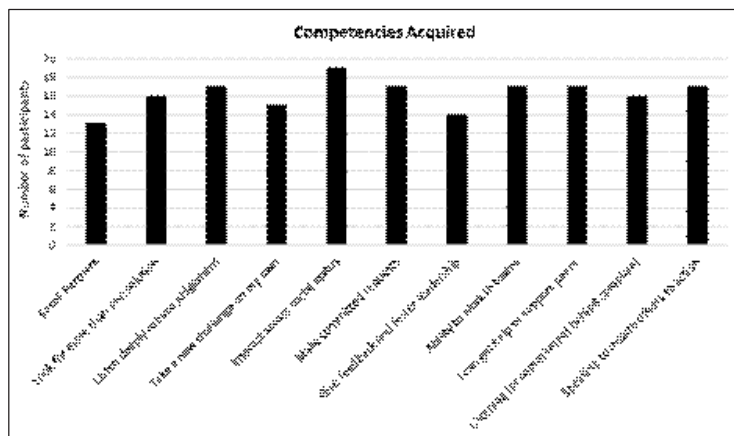


Figure 2: Skills vs the number of participants who felt they acquired them.

We stored all the projects made by participants and we saw that most had completed the challenges and made projects (outputs) requiring these skills. Within the 8 days 10 participants completed over 16 projects. The survey then reflects the confidence of the teachers in these skills (outcome). Many expressed their awareness of the expert topics we included for exposure. A few even took on the challenges of the expert skills and demonstrated these through their projects.

Competency



The survey results on the competency (Fig 3) indicated that they learned tools that would make them more effective to work with peers and management. They also started looking at solving problems in more than one way, listen deeply to others, being able to notice commitment for action behind complaints, give feedback and speak powerfully from values to enrol others. Many participants designed their CFSR directed at what they

would do differently with the skills they acquired at the workshop to and shape learning back home. They also shared these projects linking their values and cultural shifts they hope to bring through them.

Figure 3: Competencies and number of participants who felt they had acquired them

Inner Capacities

The survey indicates on inner capacities (Figure 4) indicates that all participants became more self-aware and went beyond their socialized fears even in the duration of the course. Many initially found some of the aspects of the course hard and were able to persevere and learn it. Similarly, many were uncomfortable stepping in front of an audience and sharing their insights or projects at the beginning of the course but came forward to do so at the end of the course.

They were also able to notice their socializations especially cultural and how this impacts their perspectives. We noticed that with each exercise participants became more comfortable breaking their social and professional barriers for example teachers working with educators (school management).

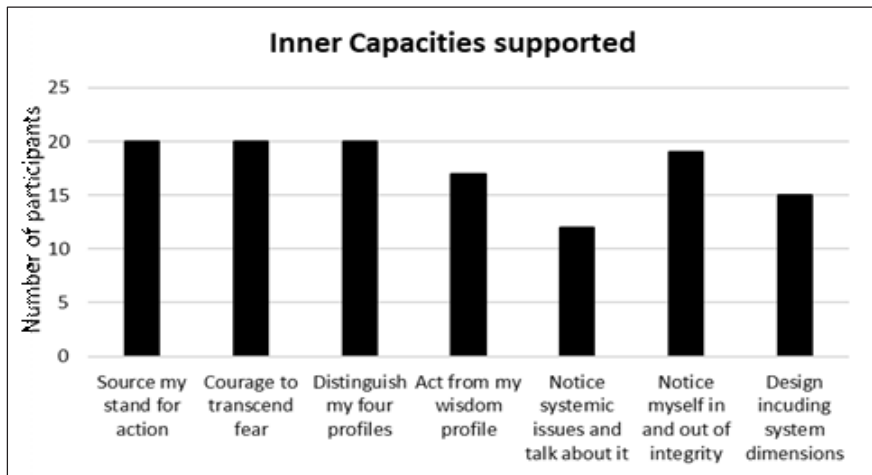
Many of them noticed systems and cultures. They and were able to design beyond technical solutions using a CFSR that included system dimensions in their organizations or classrooms. They spoke in front of an audience and shared their designed breakthrough initiatives designed. They demonstrated the courage to create and seven of the participants who were not involved with programming before the workshop started using programming with children and/or set up STEM centres. Since the course **four new STEM** centres were started by the participants at Aikiyam school, Thamarai, Auroville Institute of Applied Technology and Auroville schools.

They took up responsibility and noticed when they were in and out of integrity.

Figure 4: Inner capacities and the number of participants who believed they were

able to exhibit it through the workshop

Some insights from participants



Unlike skills, competencies and inner capacities are harder to measure directly and we share some of the insights of participants to aid this:

'I will encourage myself and the children I work with to experiment freely and try new ideas without fear of failure.'

'If I think I know something and other person is conveying the same to me I won't even listen to them, but I now realized that when I listen deeply, I was able to learn new things which I did not know before.'

'I noticed that I am able to move beyond win-lose to win-learn' [Move beyond fear of failure]

'I learnt my four profiles (wisdom, social, professional, personality), especially social profile that I am more attached to and make me think deeply about it.' [I need to work beyond my social profile]

'I noticed that I expect society to be based on how I grew up.' [My current socializations] 'I learned to be authentic and not to try to impress people.'

'I was able to look at the problem differently and get a structure for the ideas on how to go about solving it.' [Conscious Full Spectrum Response vs a partial response]

'I realized that I do not need to stop when I get one answer and keep looking for more.' [look at many ways to solve a problem to support children's learning]

CONCLUSIONS

To support future leaders in children the teachers of today themselves need to be equipped with leadership capacity. A technical training program on

programming for learning Mathematics was designed in line with capacity development to create sustainable and holistic results through a conscious full spectrum response (CFSR). A CSFR based capacity development simultaneously addresses immediate causes, systemic and cultural causes and underlying factors through skills, competencies and inner-capacities.

The skills, competencies and inner capacities targeted in this program were listed and analysed based on surveys at the end of the course, projects that participants created and in their reflections on each day.

We find that many participants felt they had acquired competencies and inner capacities along with skills in the program and this supports development and use of these skills creatively beyond what was already done at STEM land. This supports emergence rather than prescriptive design and implementation necessary for scaling. At the end of the program, the participants have demonstrated their courage to create and **seven** participants who were not involved in STEM earlier have started teaching programming and created four new STEM centres so far.

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Notes:

SHIFT IN TEACHER'S PERSPECTIVES IN MATHEMATICS BASED ON INTERVENTIONS ON INDIAN KNOWLEDGE SYSTEMS AND DISTINCTIONS BETWEEN EMPIRICAL AND FORMAL MATHEMATICS

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Abstract:

India, like many colonized countries, has an education system that follows mathematical history that is not chronological, but philosophical. The philosophy emphasizes formal (faith-based) mathematics (maths) over empirical (fact-based/normal) maths crediting the West for most mathematics and discrediting earlier work done as merely practical including that done by Indians. The cost of this emphasis is borne by children who fail to connect with formal mathematics across the world. This paper explores an intervention over six months of introduction to the Indian Knowledge Systems to teachers in India. This is done through comparisons of the scientific and mathematical aspects between the Christian calendar and the Indian Panchang. Further distinction between formal and empirical mathematics with materials, visualizations and projects were presented to them. We examine knowledge facilitators acquired and perspective shifts about IKS, their understanding of formal and empirical maths and changes in their interactions with students.

Keywords: IKS, empirical, formal, teacher perspective

Introduction

Math has been used as a tool to further cultural imperialism (Bishop, 1990). The education system in India was changed to follow the British education system after a revolt in 1857 (Macaulay, 1835) claiming “immeasurable superiority” of the European knowledge. Even now the Indian education

system in math continues what was mainly started in colonial India (Faruque, 2024). Indian teachers heavily rely on textbooks (Sharma, 2024) and these lack IKS (Indian Knowledge Systems), a study on mentions of contributions by Indian Mathematicians in NCERT (National Council of Educational Research and Training) text-books revealed that in books from 6th to 10th grade only 6 Indian Mathematicians are discussed out of a total of 33 Mathematicians (Bondu, 2020). Indian National Educational Policy 2020 highlights the need for IKS and only recently through initiatives like Akhil Bhartiya Shiksha Samagam, in 2023 the Ministry of education is working on addressing curriculum in schools and higher education institutions, and to create appropriate faculty training (Ministry of Education, 2022).

India is given credit for ‘zero’ though it should be credited for decimal system, efficient arithmetic, scientific calendar, astronomy (including trigonometry), geometry and algebra (K. Ramasubramanian, Ministry of Culture, 2022). The presumed “immeasurable superiority” of European knowledge has been questioned by C.K Raju in his book *Indian Calendar: Scientific Aspects* (2024) by comparing what is used to record time - Western and Indian calendars for their science and mathematics. After all, superior maths should translate into a superior calendar. He also describes how credit to the work done by earlier civilisations including Indian was not given by

9th ICMI-East Asia Regional Conference
on Mathematics Education

2 SHIFT IN TEACHER'S PERSPECTIVES IN MATHEMATICS BASED ON INTERVENTIONS ON INDIAN KNOWLEDGE SYSTEMS AND DISTINCTIONS BETWEEN EMPIRICAL AND FORMAL MATHEMATICS

stating that these were merely of practical value. Further independent discovery was claimed and the history of mathematics was changed from being chronological to being philosophical. The philosophy being that formal math is superior and empirical math is inferior. This allowed the West to claim credit for work centuries after it had already been done elsewhere (Raju, 2024).

Formal (faith-based) vs Empirical (fact-based) maths

Formal (Faith-based) maths is perfect in an unreal (not abstract) world of axioms and proofs based on these. Formal maths should not be confused with abstraction or generalization. An example is the definition of an angle in the IXth class textbook (NCERT, 2022), is:

"Angle is formed when two rays originate from the same end-point. The rays making an angle are called the arms of the angle, and the end point is called the vertex of the angle."

Empirical (Fact-based) maths is based on senses – students can see, feel, touch, taste and hear, can play with and verify themselves. It is imperfect in the real world and uses Zeroism: that an error that is small enough in a context can be ignored (Raju, 2012). The definition from India of angles is related to arc length. The angle in degrees is the ratio of arc length to circumference (where circumference is divided into 360 pieces). The angle in radians is the ratio of arc length to the radius of the circle. These definitions can be drawn outdoors or indoors, measured, verified and played with. Though these measurements are not possible with a toy like the pencil box.

Schools all over the world teach an odd mix of empirical and formal maths, due to which students cannot connect with mathematics. This is one reason that math is the most feared or disliked subject both in India (Gafoor, 9th ICMI-East Asia Regional Conference on Mathematics Education 18-22 July 2025, Siheung, Korea

Kurukkan 2015; The Print, 2021) and across the world (Cuemath, 2021).

Intervention

In this paper, we look at an introduction to teachers about Indic knowledge systems (IKS) and India's contribution to the world in (Raju, 2024) maths by comparing the Christian calendar with the Indian calendar. Further, the teachers are exposed to empirical (fact-based) maths with materials e.g., using the old definition of angles in India, hands-on activities with tokens related to the Bhramagupta rules of integers, use of polypad for visualization of mathematical concepts as well as Snap/Scratch programming for projects. These sessions were made available to teachers through one-hour sessions in the morning, one or two times a week over six months. In this paper, we discuss the outcomes of this intervention. The teachers work with children from 2nd Grade to 10th Grade in Mathematics in rural schools of Tamil Nadu in India.

Research Questions

1. What knowledge have the facilitators acquired, and what have been the perspective shifts about IKS?
2. What explicit distinctions and examples about empirical and formal math led to perspective shifts in teachers?

3. Has there been any change in how the teachers are interacting with children?

Research Methodology

- A survey consisting of 12 questions asking about learning from the intervention, shift in perspective, and practices adopted by the teachers was shared with STEM Teachers at C3SL.
- 22 teachers participated in the survey.
- The responses were qualitatively analysed.

Findings

Knowledge acquired and perspective shift based on IKS after the intervention:

Many teachers have gained a deeper appreciation for India's contributions to mathematics, recognizing its historical and practical significance. Key contributions highlighted include the development of the place value system, the decimal system, trigonometry, the sine series, the theory of infinitesimals, and infinite series, largely attributed to schools like the Kerala School of Mathematics. Indian mathematicians such as Aryabhata, Brahmagupta, and Bhaskaracharya were noted for their pioneering work in areas like algebra, astronomy, and the Indian calendar system, which integrates both solar and lunar calculations.

Participants also emphasized the practical and scientific approach of Indian mathematics, which connects to real-world applications, such as calculating time, angles, and heights using simple tools.

The Indian calendar, with its astronomical precision, was particularly praised for its accuracy and secular nature compared to the Gregorian

calendar. Overall, there was a shift in perspective from viewing maths as primarily a Western achievement to recognizing India's profound global contributions. Some of the responses highlighting the learnings are:

“my perspective on India’s contributions to the world of mathematics has changed deeply. the contribution I see now, the lunar and solar calendar, concept of zero. I’ve come to appreciate more deeply the interconnected global contributions that have shaped mathematical development.”

“Over the last six months, my perspective on India's contribution to mathematics has indeed deepened. I come to know the concept of brahmaguptha, bhaskaracharya and lilavathi, integers.now I could able to notice the contribution of maths in many places around me in shops. Calculation of indian calendar by sun and moon ,What is really angle mean, calculating the height of tree and building with small object I have and distance ,Radiant, pi , so on.”

“Yes, Initially, it was difficult to understand the Indian contributions, as we are already deep into European standards. A few notable points for the change are: the Gregorian calendar is based on Christian traditions; terms like A.D. and B.C. have religious origins, making the calendar non-secular; and Western education was controlled by the Church until 1870. I found that the Indian contributions are so accurate, as we have both solar and lunar calendars.”

Distinction between formal vs empirical maths:

Participants felt that empirical (fact-based) maths is practical, and rooted in real-world observations, while formal (faith-based) maths is abstract, based on assumptions and often disconnected from

4 SHIFT IN TEACHER'S PERSPECTIVES IN MATHEMATICS BASED ON INTERVENTIONS ON INDIAN KNOWLEDGE SYSTEMS AND DISTINCTIONS BETWEEN EMPIRICAL AND FORMAL MATHEMATICS

practical applications. The teachers talk about the shift toward fact-based learning, using tools like visualization and hands-on activities, has made maths more accessible and meaningful as they are able to apply it in the real world. Some responses that encapsulate what the teachers have learnt are:

“Fact based mathematics is learning the story and experimenting how things evolved and derived without assumption. Faith based mathematics as taking assumptions and explaining the concepts without understanding the core value.”

“I could apply the normal mathematics in real world and I could see and feel things like $\sqrt{2}$, π where as formal mathematics make it complicated. Though $\sqrt{2}$, π is a real number, when I think about its never ending decimal numbers it seems both real and unreal.” Here “normal mathematics” stands for empirical mathematics.

“During my school days, I found math very difficult to understand, so I memorized the concepts and formulas. But now, with the materials available, I can create projects using STEMland resources, which helps me understand the logic behind them. This has been very useful for me in both my life and my environment.”

Changes in teachers' engagement with children:

Multiple teachers share a similar shift in their teaching approach—moving from traditional, textbook- based instruction to a more hands-on, interactive, and student-centered method, use of innovative teaching methods and tools, like Scratch and practical problem-solving, has made mathematics more accessible and engaging for learners. They emphasize real-world applications, conceptual understanding, and exploration through materials, games, and technology. One of the teachers mentioned using materials that enable children to see patterns and derive formulas on their own, which is a shift from following the rules of mathematics without having an understanding of them. Another teacher recalled that children are more engaged when they

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are exploring on their own.

Some responses that demonstrate the changes teachers have undertaken in their teaching methods are as follows:

“As I teach maths using materials, I look for utility and logical aspects in fact-based mathematics. I focus on how concepts are proved or used in real life. In my school days, I learned faith-based mathematics, where they would write things down, and I would memorize them without understanding the logic or real-life applications”

“When I work with children, I do some research and prepare how to introduce connecting with real life and use materials that help them to derive the formula or notice pattern.”

Discussion

IKS supports teachers in India be more appreciative of the contributions of India to global mathematics. Teachers feel more confident about making math more accessible for children even though this is not how they learned maths. However, this work is not only for children in India, but for all children who have borne the cost of the philosophy of superiority of formal math over empirical maths. Once teachers can see the distinction between formal and empirical mathematics they take an effort to make math more accessible to children. This perspective transcends polarities that can arise from the history of Mathematics.

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