INTRODUCTION OF STEM/STEAM CURRICULUM IN GENERAL EDUCATION

This document carries all the insights presented by the participants in the Core Group set up by the Ministry of Education and made available as written submissions.

Prepared by Dr. Chandra Embuldeniya
Chairman, STEM Working Committee of the NSF

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STEM
STEAM

STEM is consonant with STEAM as referred to in education with the integrated experiences of Science, Technology, Engineering, Aesthetics, Arts, Humanities and Mathematics

- STEM Strategy General Education (real-life problems, new innovations, commercialization)
- STEM/STEAM mindset
- Low-cost approach
- No major reforms in curriculum

Our Goal – The Core group upholds the principle of STEM

Our goal is to provide students with cognitive, affective, and psychomotor experiences that will help them develop a mindset that uses scientific knowledge to find technological solutions to real-world problems using mathematical models and engineering designs.

NATIONAL SCIENCE AND TEACHING ASSOCIATION (US)

STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (NSTA).

NSTA was founded in 1944 and headquartered in Arlington, Virginia. It is an association of science teachers in the United States and is the largest organization of science teachers worldwide.

STEAM

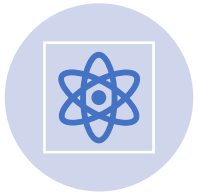
1 Many silos of knowledge developed around science which is the study of solids, liquids, gases, and energy.

2 Engineering and Medicine are multidisciplinary.

3 We do not teach Engineering in General Education.

4 We bring Designs experience for Engineering

5 Technology is the solution



6 Mathematics is critical to connect technology to designs and science

7 Aesthetics is Arts, Social Sciences, and Humanities

STEM Competency Framework

STEM Competency Framework is a detailed document containing the pedagogy of the tweaked curriculum of the normal science education and the connection to technology, engineering (designs), aesthetics, and mathematics

- Knowledge – Cognitive Domain
- Skills – Psychomotor Domain
- Attitude – Affective Domain
- Mindset – Applications with integrated experience
- Paradigm – New strategy, 4IR

Syllabus Making

- i) The current syllabuses will be slightly tweaked to accommodate the points where students get STEM experiences. This will be accomplished rapidly by conducting several workshops with expert teachers to identify points for STEM-related integration with relevant subjects. These landmarks will be printed and provided to the teachers with suggested activities

Activity Mining

- ii) Generating activities with expert panellists. Many examples are available online. Use as much as locally accessible resources. Requires assessment of cost if using standard material
- iii) Conducting several workshops islandwide in stages for teachers on the activities without making them feel an additional burden. The workshops will be in the hybrid model. The teachers will find these activities fun and will engage in collaboration with teachers of other disciplines in the classrooms.

Standard Material

- iv) Conducting several workshops islandwide in stages for teachers on the activities without making them feel an additional burden. The workshops will be in the hybrid model. The teachers will find these activities fun and will engage in collaboration with teachers of other disciplines in the classrooms.

SBA Methods

- v) Develop SBA with the help of expert teachers onto a digital platform commonly available for all teachers to produce continuous assessments. Take the results in vii) below into consideration for preparing the SBA approach.
- vi) The performance of students during SBA on a trial basis to be checked with their present outcomes now at senior level and career level. Prepare a report on the level of success at the senior level and career level correlations.
- vii) Select a sample of schools without SBA during the SBA and check the performance of students at present at senior level and career level. Prepare a report on the level of success at the senior level and career level correlations.
- ix) Discuss the outcomes of the research in vi) & vii) with administrators and principals. Identify the weaknesses and strengths of SBA

Administrators

- x) The administrators will be brought up to spec on the transformation with training on the areas of relevance. The administrators engage productively with innovative solutions to challenging problems.

The Beginning of STEM Journey

- xi) Developing a set of documents connecting the landmark points discovered during the workshops to practices giving STEM experiences and distributing to schools islandwide. It could be done on web applications also to save costs. This will continue periodically as the learning expands on the STEM experience.

Other Schools and Traditional Knowledge

- Special treatment of schools where Science is not a subject.
- For example, Economics can be connected to Mathematics and Environment. History can be connected to irrigation technology and the civil engineering of ancient architecture. Geography can be connected to agriculture and climate resilience. Other subjects connect with areas of science in life.
- Traditional knowledge was within the surrounding environment that provided livelihoods agriculture and food, dependent on predictions of weather and soil.
- The network of irrigation and migratory measures shows the strengths of traditional knowledge.
- Traditional ways of doing things have science-based principles.
- We may develop monographs of traditional thoughts and applications to support STEM learning applications.
- Innovations train teachers to be tolerant and patient with failures as those failures are the pillars of success.

A Justification

- 4IR is disruptive in supporting livelihoods and keeping traditional jobs
- 4IR presents a major challenge for capacity development
- STEM literacy helps informed decisions
- STEM helps reduce the cost of failures and improve productivity
- STEM workforce draw investments in technology-related production
- STEM provides better career choices and adaptability to disruptive changes in the world of work.

Expected Outcomes

Given the aforesaid, our proposals are designed to produce the following outcomes using STEM approaches.

- i) To develop a mindset integrated with STEM knowledge.
- ii) To develop students capacity to articulate the STEM aspects of technology solutions.
- iii) To enable science learning with an emphasis on STEM where relevant.
- iv) To develop teachers capacity for innovative STEM activities to engage students with enthusiasm.
- v) To upskill the administrators to empower the educators to deliver SBA in their domains.
- vi) To recognize SBA as an integral part of STEM assessment in general education.
- vii) To develop applications in curricular and co-curricular activities.
- viii) To enable the teachers to map the subjects to solutions in STEM
- ix) To gain an advantage from the education reforms in line with STEM
- x) To enable students to gain authentic experiences in general education
- The outcome of these proposals is the “STEM Mindset”.

Relationship to Non-STEM Curriculum

Other areas such as Arts, Humanities and Commerce should have STEM

The students should be made to feel they too are part of the STEM revolution

In the 4IR it is a science that precedes their learning experience

The outcome is a technology solution appealing to the human mind and addressing practical life situations.

The appeal to the human mind is so important in technology it determines the success or failure of the adoption of technologies.

Students can well understand what makes products attractive to customers

So, the teachers have to guide the students through various STEM-related activities.

… Non-STEM Curriculum

- The STEM approach makes our solutions sustainable with added value.
- Requires knowledge from history, geography apart from science.
- Solutions in the product life cycles and biodegradability.
- The social aspects such as equity, inclusivity, equality, in treating gender, race, region, income levels, family backgrounds, religion are some issues that will get the students to develop mindsets from the start.
- Language has high utility value as a determinant in scientific knowledge.
- We would demonstrate in the workshops how the aforementioned Arts, Humanities, Commerce and Aesthetics get integrated into the learning process.
- Students are given opportunities to develop their knowledge and experience in STEM through immersive hands-on open-ended exploratory work. These activities involve guided productive teamwork.

Implementation Time Frame

The three phases of introduction are as follows.

- Phase 1: Grade 6 and above where STEM subjects (all five streams are taught)
- Phase 2: Grade 6 and above where science and technology are not taught
- Phase 3: All schools below Grade 6
- The timeline could be as follows

	4 months	4 months	4 months	4 months	4 months	beyond
Phase 1	Prepare	Testing	Implement	Implement	Implement	do
Phase 2		Prepare	Testing	Implement	Implement	do
Phase 3			Prepare	Prepare	Testing	Implement

Implications for Teacher Training

- The teachers engaged with STEM subjects are competent in their domains.
- The only addition is the activities where they must engage in student activities.
- A minimal standard ready-made package and other material that teachers develop innovatively with the students.
- The success depends on the cooperation of the teachers.
- The new activities will not put any additional burden on teachers.
- The teachers are likely to find these activities very engaging with the students.
- The new activities are those that connect science with designs, mathematics, aesthetics, and technology.
- These are not mind-boggling but very simple fun-filled learning activities.
- Design is an area that has to be mentored for all teachers.

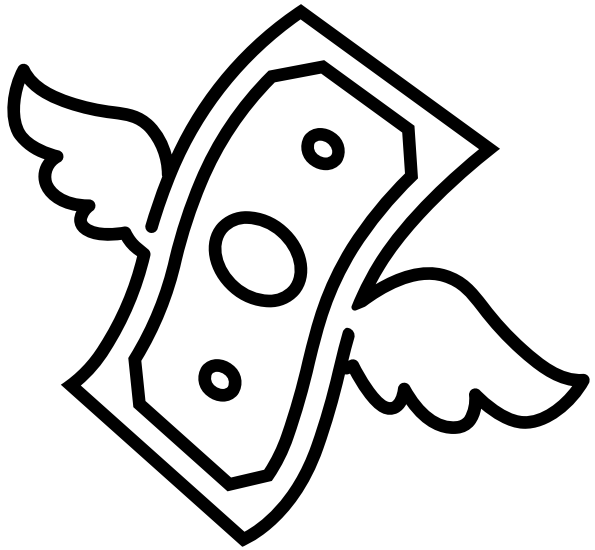
Teacher training …

- The guidance on activity planning will be given to teachers
- Teachers have classroom management and organize outdoor activities.
- New knowledge and the skills teachers acquire
- Teachers' self-assessment program online
- The teachers develop the right mindset for STEM
- The real-life situations in the STEM activities are authentic life experiences.

Teacher’s role in STEM

- Students are diverse in their uptake of knowledge
- The teachers should recognize the diversity in STEM
- SBA will be designed to highlight the students' learning needs in the formative assessments.
- The teachers can guide students in choosing what, how, and demonstrating the learning to give them the inspiration to carry out their innovative learning.
- This will create a friendly environment for the students to practice STEM.
- Students are encouraged to innovate while learning new scientific concepts.
- The teachers’ support for the students in innovative work is essential.
- The students need to solve any design problems or mathematical problems to produce the technology this support by the teachers will help.

Implications for Finance and Other Resources



- Ideally, there should be seed funding for startups and the involvement of the government is partly to satisfy this requirement.
- But now we have to do a lean startup with collaborative work by engaging partners who would contribute to the pool for adding tangible value.
- As such we do not feel the burden of financing the new operations will be felt due to the voluntary nature during work hours.
- Some subsistence from the budgeted allocations will be spent.
- The material already available from the market may have to be purchased on a tender when the financials improve.

Implications for Infrastructure at the School Level

- STEM learning does not need any large investments in constructing new infrastructure for education.
- The existing laboratories and the living and studying environment are sufficient to get started with the plan of implementation.
- The existing laboratories can be supplemented by the infusion of a few standard STEM activity related tools.
- No new capital expenditure other than the government plans already in place for development will be required.

Implications for Assessment

- We are concerned about three types.
- The **summative assessments** will be developed as needed with the new activities. These are usually midterm, end of term, and end of year assessments. We have to develop these assessments with appropriate modifications.
- In STEM mindset development **formative assessments** are very important. Formative assessments will be conducted throughout the year through the lessons using SBA.
- **Diagnostic assessments** will be used to understand the difficulties of both teachers and students. These assessments too shall be developed in the workshops.
- The SBA is dependent on the teachers for developing assessments. The teachers will be guided on the assessment development through online media.
- The STEM approach to learning is **not a one solution fits all problem**. STEM can have several solutions for problems and thus teachers have to develop their insights on the possible solutions through engagement and reasoning with the students.

Implications; for Education Administration

- The administrators' role in STEM
  - Empowering the SBA,
  - Recognizing the STEM performances (new assessments) at the national level,
  - Supporting necessary facilitation with equipment wherever needed,
  - Arranging STEM-related skills development for teachers,
  - Improving the knowledge about STEM practices,
  - Continuing to monitor and provide feedback on results,
  - Ensuring the timelines set for capacity development work is satisfied,
  - Equitable distribution of teachers with necessary skills in the school system,
  - Empowering schools by providing technology platforms to report STEM outcomes, etc.
- The mindset of the zonal officials including the directors who preside in these transformative experiences need change.
- The STEM program will put a special coaching program for the zonal officials who are involved in STEM education administration

Aspects of Community Participation, if Any.

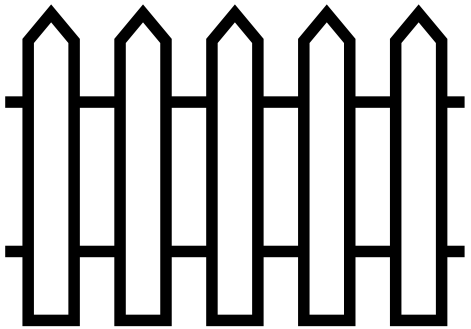
- As a stakeholder, community participation is of vital importance.
- The parents must understand the new addition to the students learning and knowledge and how it will help in students reaching their life ambitions.
- The community also can participate in school exhibitions and learn to generate enthusiasm about STEM.
- Students can participate in the “Pradeshiya” level development activities as observers and where STEM has application.

Demonstration of STEM Curriculum Delivery with Examples

- The **Uva Wellassa University** was developed as a STEAM university. The principles of application are similar. The STEM content was delivered through multidisciplinary and interdisciplinary programs. Aesthetics were given a very important role through Broad General Education (BGE) and Essential Skills (ES). Every student had to learn computing, communication, economics, geography, mathematics, quantitative reasoning, languages (Tamil for Sinhala and vice versa).
- The programs focused on gaining technical knowledge and practical experience in the areas of the national importance of primary level resources such as tea, rubber, palm, minerals, and aquatics.
- There were other streams in management, computing but those streams too had the BGE and ES with multidisciplinary approaches. The student whom we have traced came out into the world of work very successfully.
- The **STEM Working Committee at the NSF** conducted brainstorming to develop the approaches and discussed the pedagogical variants and modes. Several workshops were held to understand the feasibility of figuring out the transformative experiences for students within the existing syllabus.

Issues and Potential Obstacles

- There will be practical obstacles due to the pandemic in exploring F2F people engagement. As such more of the new normal hybrid mode becomes useful.
- Financial resources may be scarce. Engaging private institutions in partnerships (PPP) could be explored.
- Reforms have to be driven through the NIE and the Ministry to gain positive responses.
- The STEM implementation should be carried out through the same departments as Science, Technology, Mathematics and Aesthetics subjects.
- It is particularly important not to set up a special facility for STEM. The reasoning is that any special unit would become another silo and becomes a hindrance to the success of STEM learning.
- The Science division should take the lead role in STEM since according to the plan it is the holder of the curriculum intersections. The other STEM divisions as mentioned earlier would be enlightened in STEM through frequent engagements during the preparatory period. It will be incumbent upon the other divisions in the Ministry and the Department to have STEM built into their curricula as activities. We will illustrate how this could be achieved during the workshops.



YOUR TOTAL COMMITMENT AND CONTRIBUTION IS ESSENTIAL FOR SUCCESS

This is a national responsibility

Thank you for your patience