Views in connection with the "Meeting to brainstorm on ways and means to renew the focus on Science, Mathematics and Technology in School Education (Elementary and Secondary education)" organised by MHRD at Shastri Bhavan, New Delhi 4 July 2014.

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With inputs from colleagues at the Centre.

1. **Rationale**

Science and mathematics are valued for their practical utility, such as in their application to everyday life. More importantly, they nurture a variety of thinking and reasoning abilities among learners and practitioners, like logical thinking, quantitative and analytical reasoning, critical questioning and evidence based justification and argumentation. Their knowledge and practice contributes to the democratic functioning of society and to the economy as it is imperative for increasing the productivity of people at work. Besides, they open up a multitude of opportunities for productive employment.

Technology manifests as products, as a distinct body of knowledge, as activities that people engage in and in terms of the volition of people, that is the capability of conscious choice, decision and intention. Technology is far more than mere application of science and mathematics, and needs to be seen in terms of the "making and doing" practices as well as designing involving visuo-spatial abilities among all people and for sensitising people on sustainability issues, eg. life-cycle of artefacts, energy sources, etc.

Much as we would like to improve science, technology and mathematics education (STME) in schools, the progress in this regard has been at best unsatisfactory over the years. These are critical subjects in the general education of citizens of any nation state. A mission on improving quality of education needs to refocus on these subjects as much as any other. In the existing situation of competitive examinations, which clearly do not test innovations, the nation's creative talent is wasted. Modifying the existing screening mechanisms can work to the nation's benefit.

2. **Objectives**
   - To improve student engagements in and their gains through STME in schools
   - To create a culture of "making and doing" and documentation of processes
   - To encourage collaborative engagement of teachers in schools with planned and coordinated sustenance in the form of material access (resources, their documentation and access), institutional support (work load, scheduling, flexibility and coherent policy guidelines, etc.) and intellectual support (content experts, mentoring, etc.)

- To involve all stakeholders in education – school management, State and Central bodies involved with implementing policies and monitoring education (eg. CBSE, SCERTs, Education departments), developing and implementing curricula (eg. NCERT, SCERT), government bodies and agencies involved in higher education and research (eg. UGC, Universities, RD institutions) and teacher professional development (eg. NCTE, DIETs, BRCs), as well as voluntary organisations involved in school education.

3. **Core elements / components**
   - Teachers and students engaging in "making and doing" activities.
   - Teachers professionally prepared and supported to engage in meaningful science, technology and mathematics activities
   - Detailed documentation of process of engagements – not just product outcomes. Role of ICT must be explored for this purpose.

4. **Stakeholders**

Important stakeholders whose needs must be addressed:

Students Need:
   - To be engaged in tasks or activities – even reading, drawing and writing can be engaging activities – in order to learn.
   - Weeding out of those practices in the educational system that (a) reward rote learning, (b) reward consistent high performance, and (c) punish risk taking.
   - An environment that tolerates learning from failures and therefore motivates children (and teachers) to be creative, and think out-of-the-box.
   - Encouragement for perseverance, by providing positive reinforcement for persevering on tasks; and by not rewarding only the fastest correct answer.
   - Need examinations that test their thinking, reasoning and abilities to be creative, not just their ability to memorise and reproduce.

Teachers Need:
   - In-situ (closest to their work place) and sustained professional development and mentoring (partners? mentors?)
   - Support – material (print, ICT, lab resources, space, maps), institutional (policy, trust, scheduling), and intellectual (subject experts, college teachers, researchers).
   - To belong to collaborative teacher communities, including researchers and teacher educators.
   - Schools that allow for flexibility of schedules and space use, coordinate on their behalf with educational bodies to provide the facilities and support that teachers need.
   - Schools that have transparent systems in place – that make expectations known and have shared evaluation criteria.
   - Evaluators who include peers, students and community.

5. **Planning at National/State/District/SubDistrict and School level**

(a) Form **"Working Groups"** (**WG**) (decision making bodies, with certain degree of autonomy, and clearly stated terms of reference) at the National (NWG), State (SWG) and District levels (DWG), with members from all stakeholder institutions with decision making capacity.

(b) Provide platform for collaborative (among teachers, teacher educators, and any other stakeholders) development of curated repositories and inventories of available resources (books, lab kits, activity sets, maps, ideas, projects, etc.) at all levels - District, State and National – one of the responsibilities of **WG**s. The **NROER** platform is already being developed with this goal in mind. It can be effectively used for the purpose (nroer.gov.in).

(c) Develop all teaching-learning activities around the school laboratory and library as well as the school's local environment (physical, natural, social). Student engagements must be centred around "making and doing", in any space – classrooms included.

(d) All examinations should include questions which involve "designing and doing". This will lead to learning of the processes of science – an engagement in science that is not merely reading and writing of scientific facts and procedures.

(e) *A Nation-wide Teacher Professional Development Mission – the BEST project*
A model for continuous and sustained teacher professional development to enable maintenance, adaptation, use and development of resources and strategies for innovation among students and the community, with in-built strategies for documentation of all activities.

Through suitable incentives and *collaborative organisational mechanisms*, a scheme has been formulated in order to create a climate for sustained professional development of science and mathematics teachers. The scheme calls for a *nation wide coordinated mission* involving MHRD and DST at the Centre, and all regulatory and implementing bodies for school and higher education at the central and State levels (Working Groups at all levels to guide and monitor the process). It seeks to reorient and strengthen the existing systems to support a climate of innovation by teachers and students at school level.

The detailed scheme (DPR) has been prepared by HBCSE for DST in collaboration with several stakeholders in education. The mechanisms suggested in the scheme focus on building communities consisting of teachers, pedagogy experts and science and mathematics content

experts to encourage and support committed teachers in their effective teaching-learning practices in science and mathematics.

6. **Implementation issues at National/State/District/SubDistrict and School level**

   (a) Support teacher communities – both locally and non-locally through access to material (eg. NROER), institutional flexibility and intellectual mentoring.
   (b) Create local resource centres (eg. Block level, District level, etc.) for learning, brainstorming, exchange of ideas among local school networks.
   (c) Ensure spaces for "making and doing", such as laboratories, fabrication workshops equipped with tools and reusable / recyclable materials.
   (d) Create, strengthen networks of local schools, as envisioned by the Kothari Commission (1964-66).
   (e) Develop facilities within existing teacher support organisations, such as BRCs, DIETa, etc. for teachers and local community to document and disseminate all activities conducted at the school level.
   (f) Initiate fora at District, State and National levels for teachers to share through documentation and presentation all their professional activities – innovations, successes and failures in teaching-learning – with their peers. Provide for expert mentoring and partners.

And more importantly,
   (g) Generate coordinated and coherent policies and circulars that specifically aim to encourage action and innovation among collaborative communities of teachers.

7. **Monitoring**

Build monitoring and evaluation into the mechanisms through transparency, as well as self and peer evaluations. Use the **Working Groups** to involve all stakeholders in supporting and monitoring. Use existing educational agencies – education offices, BRCs, DIETs, SCERTs to route circulars and funding. The engagements involving all the stakeholders will be monitored and facilitated through an online platform. Data analytics and visualization will be used to inform the visitors of the status of implementation.

8. **Evaluation**

Develop a scheme that clearly states the objectives to be met and matching evaluation criteria. Share these with all stakeholders. Include self and peer monitoring and evaluations.

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