DESIGN, DEVELOPMENT AND PRODUCTION OF LOW-COST SCIENCE EQUIPMENT

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Science Education Programme

In general, the objectives of a science education programme of a developing country may include the following:

(a) Curriculum development, including the pilot stage of testing methods and materials.

(b) Organization and development of pre-service training of prospective science teachers.

(c) Organization of regular in-service courses, including enrichment programmes, to equip teachers for the new science curriculum.

(d) Development of instructional materials such as textbooks, teachers guides, science and other equipment.

(e) Provision of laboratory/workshop facilities in teacher training institutions.

In India, education is a State subject, and the Central Government is mainly responsible for laying down broad policies for concurrence by the States and ensuring co-ordination of the various activities. The Central Government supports experimental projects academically and financially, and also functions as a monitoring agency for the programmes of external assistance in the States. The National Council of Educational Research and Training (NCERT) is the academic agency of the Central Ministry of Education for bringing about improvements in all aspects of school education.

This paper sets out what is, by and large, the Indian experience in the design, development and production of low-cost science equipment. Some aspects of it would be of relevance to many developing sister countries faced with the problem of equipping their schools and teacher training institutions.

The science education programme in India has been in existence for over a decade. It was primarily undertaken to support a curriculum development programme of teaching science through practical activities and real experiences. A strategy had to be adopted whereby simple equipment made from indigenous materials and using local resources could be made available to the teacher in the classroom. Incidentally, the development of such science equipment in the form of compact, portable laboratories or kits also helped to conserve much-needed foreign exchange.

Curriculum and Ideas for Design of Equipment

While the broad outlines of objectives and curricula for school education are formulated at the national level, the actual details are drawn up by State Education Departments and State Boards of Education. The expertise of universities and research institutions throughout the country is utilized in developing model curricula for schools. The draft curricula, the syllabuses, and instructional materials with innovative ideas responsive to national needs, are made available to the States for trial and adoption or adaptation according to the local needs and resources. Thus the whole curriculum development process initiated at the Centre becomes a decentralized activity at the State level through a network of curriculum development centres.

At the State level, a number of agencies become directly or indirectly concerned with the curriculum. The State Institutes of Education, State Institutes of Science Education, Boards of Secondary Education, the Textbook Bureaux, Guidance Bureaux and other similar specialized institutions are also involved in curriculum work in some form or the other. The NCERT co-ordinates the work of these bodies.

In science subjects, experts of the curriculum body spell out the specific experiments or the purposes of the design, and identify the type of supporting equipment required. In addition, they scrutinize some of the conventional equipment readily available in the market and report on their merits and shortcomings. With this information at his disposal the designer makes a prototype. This prototype is then reviewed in advisory committee meetings comprising interested teachers, eminent scientists and staff of the design centre. At these meetings the product is thoroughly examined and suggestions are made to help improve the design.

At the design stage it has been found useful to involve teachers who are the actual users of the equipment. Encouragement for their participation is effected through design competitions and appeals to teachers through different science teachers' association, regional science officers, teachers' centres etc. Professional designers of science equipment have also been invited to participate. In addition, resource materials from international agencies have proved very useful.

Types of Low-Cost Equipment

Depending upon the requirements of the science education programme, the designer may start designing one or more of the following:

(a) A pack of equipment, for demonstration or pupils' activities, based on the curriculum for a particular class.

(b) Inexpensive substitutes for conventional laboratory equipment.

(c) Equipment needed for use at science centres and science fairs. (Though these items are not covered by the curriculum, they do have a unifying effect across the arts and science disciplines of the curriculum, and also tend to promote public understanding of materials and practical techniques.)

The pack of equipment in (a) above, may be a kit for teaching electricity to the students of Class VIII or a primary science kit for teaching science to the students of Class III. In all cases, the designer has to grasp the spirit of the particular curriculum, try to follow the textbook sequences and illustrations, and model his design in such a way that the same equipment could be modified for use in different classes. The pack of equipment for a particular class level ought to be portable, act as a mini-laboratory suitable for use even in rural schools where laboratories for science teaching are non-existent. The cost of equipment may be reduced to the minimum, utilizing most of the items which are readily available in the local market. Items need to be sturdy in construction and simple in operation so that the children can use them without any fear of damage. The NCERT kits produced are designed to provide the following advantages: compactness; multi-purpose use of items; economy of time in setting up experiments; economy of consumable materials; portability; provision for teacher's innovation; low-cost and use of indigenous resource materials; and easy replacement of lost or broken items.

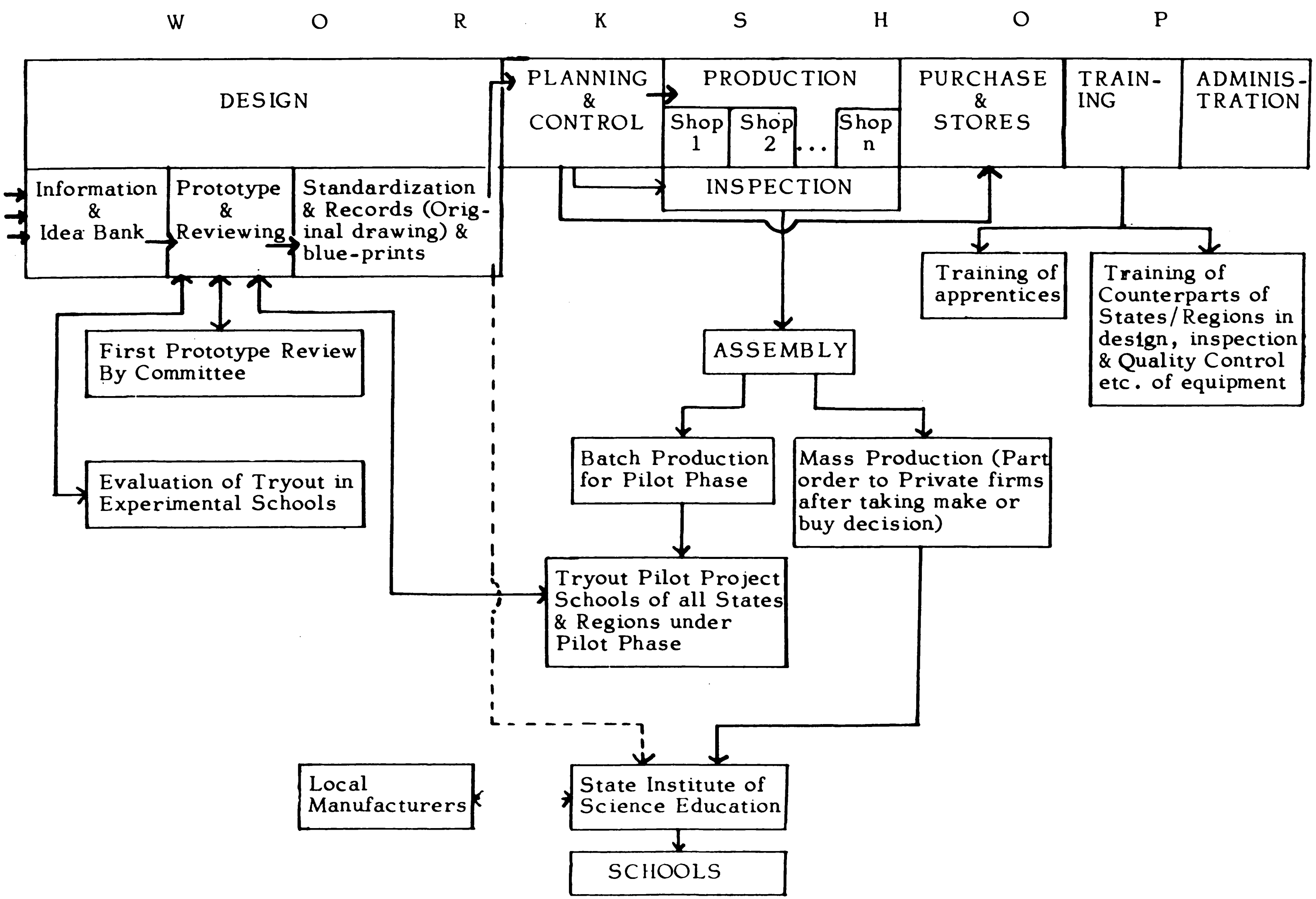
An essential component of a kit is a guide containing a list of items with sketches, detailed descriptions and instructions on how to use each item. This facilitates not only the proper use of the kit but also helps replacement of any part rendered unserviceable.

Production

Once the design has been worked out, the design office makes the drawing of the approved model with complete technical specifications. The drawings are then passed on to the production section for batch/mass production through the production-planning and control section. The various functions of the Centre producing low-cost science equipment are as suggested in the diagram. With expert advice from the Centre, the States draw up their plans and arrange for the necessary funds to meet the equipment needs of schools over a specified period. A region which does not have any local industries may prefer to request the Centre to undertake the mass-production for them, whereas a region located in the industrial belt may prefer to get the equipment manufactured locally with or without modifications as shown by the dotted lines in the diagram on page 36. The Centre can provide the design specification and necessary information for them. In addition, the State may ask the Centre to train their technical staff in the inspection and quality control aspect of equipment production.

Though the science kits have been very effective in implementing the science education programme, mass-producing and supplying them pose many problems, particularly in a large country like India. For instance, a State with 30,000 primary science schools distributing at the modest rate of 2,000 primary science kits per year, will need 15 years to cover its entire school population. By this time, not only would the population of the State have increased considerably but also the content of science would have altered completely. As the State cannot wait so long to see all the schools with a kit, it should encourage the use of local resources for the practical aspects of science teaching. Using illustrated pamphlets and booklets published by the design centres, teachers can fabricate educationally-useful equipment out of locally-available materials. If need be, they will seek the help of local craftsmen. Excellent innovative teaching aids may be made out of scrap materials like used razors, used plastic and tin containers, used bulbs, aluminium foils in cigarette packets, steel straps or packing boxes, other day-to-day household goods, and common materials like wood, bamboo (which may be used as rigid pipes, cylinders, measuring vessels, syringes, and frames for structures), the hollow stalks of some leaves and flowers (for making flexible pipe), hard thorns, different types of fruits, clay, straws. All these are available even in the remotest villages.

SUGGESTED ACTIVITIES OF THE DESIGN, PRODUCTION AND EVALUATION CENTRE AT THE NATIONAL LEVEL



ANNEX

BASIC EQUIPMENT FOR A LOW-COST SCIENCE EQUIPMENT PRODUCTION CENTRE

For design and development activities combined with an average production worth £100,000 (on no profit, no loss basis), a modest requirement of equipment is given below for a workshop having nearly 2,000 sq. metres of covered area and employing nearly 100 persons. The list may prove uneconomical for small countries. In such cases neighbouring countries may decide to establish a common regional centre to cater for their needs.

A. Design Section

1. Drafting machine, drawing board, instrument box, set squares etc.
2. Ammonia printing equipment.
3. Electronic stencil cutter.
4. Duplicating machine.
5. Screen printing equipment.

B. Development Section

1.	Tool room lathe	- Height of centre - 150 mm distance between centres - 500 mm
2.	Precision lathe	- Height of centre - 100 mm distance between centres - 300 mm
3.	Screw cutting lathe	- Height of centre - 200 mm distance between centres - 1 metre
4.	Drilling machine	- Capacity - 18 mm Height of work - 200 mm
5.	Padestal tool grinder	- Wheel dia - 400 mm
6.	All types of handtools for fitting jobs	

C. Machine Shop

1.	Screw cutting lathe	- Height of centre - 200 mm distance between centres - 1000 mm
2.	Screw cutting lathe	- Height of centre - 200 mm distance between centres - 1 metre
3.	Precision lathe	- Height of centre - 200 mm distance between centres - 1.5 metre
4.	Screw cutting lathe	- Height of centre - 175 mm distance between centres - 1.2 metre
5.	Shaping machine	- Stroke - 600 mm
6.	Padestal tool grinder	- Wheel dia - 400 mm - 3 Nos.
7.	Power hacksaw	- Max. dia of work - 150 mm
8.	Universal milling machine	- Vertical travel - 300 mm Horizontal travel - 320 mm Cross travel - 200 mm
9.	Vertical milling machine	- Swivel head, travel of head - 200 mm Vertical travel of bed - 300 mm
10.	Horizontal milling machine	- Vertical travel - 800 mm Horizontal travel - 800 mm Cross travel - 500 mm

11.	Universal tool & cutter grinder	- Longitudinal traverse - 400 mm Cross traverse - 150 mm Vertical movement of wheel head - 100 mm
12.	Cylindrical grinder	- Max. work diameter - 150 mm
13.	Surface grinder	- Table travel - 710 mm Vertical travel - 300 mm Cross travel - 235 mm
14.	Engraving machine	- Horizontal travel - 200 mm Vertical travel - 300 mm Cross travel - 200 mm
15.	Turret lathe	- Bar capacity in collet - 18 mm
16.	Semi-automatic capstan lathe	- Bar capacity in collet - 18 mm Bar capacity in chuck - 50 mm
17.	Pillar drilling machine	- Capacity - 25 mm
18.	Bench drilling machine	- Capacity - 12 mm
19.	Spring winder	
D.	<u>Die Stamping Section</u>	
1.	Punch press	- Capacity - 40 ton
2.	Hydraulic press	- Pressure - 400 kg./cm^2
3.	Lathe (gap bed)	- Height of centre - 200 mm distance between centres - 1 metre
4.	Fly press, hand-operated	- No.4 and No. 6
E.	<u>Sheet Metal & Fitting Section</u>	
1.	Power-operated sheet cutting machine (guillotine shear)	- Length of cut - 2 metres Max. thickness of sheet - 3 mm
2.	Power-operated sheet bending machine	- Length of bed - 2 metres Max. thickness of sheet - 3 mm
3.	Hand-operated shear	- Max.thickness of sheet - 16 SWG
4.	Drilling machine	- Capacity - 12 mm
5.	All sheet-metal and fitting hand-tools	
F.	<u>Carpentry Section</u>	
1.	Wood turning lathe	- Height of centre - 100 mm distance between centres - 1.2 metre
2.	Thickness planer	- Max. thickness of work - 150 mm
3.	Foot-operated fretsaw	
4.	Band saw	
5.	Circular saw	- Diameter - 400 mm
6.	Disc and belt sander	- 300 mm disc
7.	All carpentry hand-tools	
G.	<u>Plastic Moulding Section</u>	
1.	Plastic injection moulding machine (manual)	- 200 gms. capacity
2.	Plastic injection moulding machine (manual)	- 60 gms. capacity
3.	Plastic injection moulding machine (semi-automatic)	- 100 gms. capacity

4.	Plastic injection moulding machine (manual)	-	30 gms. capacity
5.	Blowing-moulding machine (manual)	-	100 gms. capacity
6.	Blowing-moulding machine (manual)	-	30 gms. capacity
7.	Plastic scrap cutting machine	-	
8.	Vacuum forming machine	-	450 x 450 x 200 mm capacity
9.	Plastic coating equipment		
H.	<u>Optics Section</u>		
1.	Glass blowing equipment	-	Set of glass blower tools - 2 sets Blast burner - 2 Nos. Small air blower with air flow and pressure valve - 1 No.
2.	Lens grinding machine		
3.	Polishing machine		
I.	<u>Electro-plating Section</u>		
1.	Rectifier/motor generator		
2.	Tanks, salt accessories		
3.	Polishing machine		
J.	<u>Welding Section</u>		
1.	Gas welding equipment		
2.	Arc welding equipment (transformer, electrodes etc.)		
3.	Spot welding machine	-	Max. sheet thickness - 18 SWG
K.	<u>Foundry</u>		
1.	Blower and pit furnace for floor moulding		
2.	Crucibles and all foundry tools		
3.	Die casting machine (medium)		
L.	<u>Painting Section</u>		
1.	Spray gun		
2.	Air compressor		
M.	<u>Electrical Section</u>		
1.	Coil winding machine		
2.	Multi-meter and other metres		
3.	All hand tools for electrician		

N. <u>General</u>

1. Measuring tools
2. Inspection tools and gauges
3. Cutting tools
4. Portable drilling machine with accessories for converting it into other powered tools
5. Conveyor belt for inspection and assembly purposes
6. Sundries