ISSN 2976-1190 (Online)
Journal of Engineering and Sciences
Vol. 1 Issue 1

Stem Laboratory for Schools in Gandaki Province and Beyond

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(Manuscript Received 000 0, 2022; Revised 000 0, 2022; Accepted 000 0, 2022)

Abstract

The principal motive of this study is to design a master plan that promotes STEM education integration in the academic sector and strengthens the laboratory settings of the schools in Gandaki province and beyond. This study has summarized the essential components for developing a STEM lab, guidelines for the design, and a tentative cost estimate for a school-level STEM lab. Moreover, this study provides insights into STEM Club formation, its objective, and the curriculum for training trainers in the STEM Lab. Evaluation parameters for overall STEM performance have also been highlighted in this paper. Therefore, this study will be an essential document to guide the academic sector regarding STEM laboratory design, the implication of STEM club formation, and organizing teacher training, cumulatively becoming a driving force for STEM education in Nepal.

Keywords: Master Plan; Guidelines; STEM Lab; STEM Club

1. Introduction

"STEM," an acronym for science, technology, engineering, and mathematics, was initially proposed by the National Science Foundation (NSF) of the USA in the 1990s to emphasize the need for these four disciplines in the education community and society [1]. STEM education is a practical method of teaching and learning that focuses on learning by doing. Unlike the traditional approach, this multidisciplinary approach interlinks science, technology, engineering, and mathematics in contexts that connect with community, society, and nation, preparing the workforce required to keep the country competitive in the global economy. The STEM lab is an integrated environment that supports hands-on learning. STEM lab plays a crucial role in arousing students' interest in science, technology, engineering, and mathematics. Laboratories applications are central to effective, permanent, and enjoyable learning. The advocation of STEM education will benefit the nation's economy and individuals' comprehensive abilities [2]. Currently, in Nepal, the traditional mono-disciplinary approach is more prevalent in the academic sector, due to which there is a gap between theory and practice. According to the report on higher education published
by UGC in 2021-out of 40921 students enrolled in higher education during the year 2019/20, only 23% were enrolled in STEM disciplines [3]; in order to improve this status interest in school students about STEM disciplines should be aroused from school interests integrated approach to teaching the STEM disciplines with a meticulously designed STEM lab is the need of today.

2. Methodology

The work commenced with reviewing documents, literature, and the National Building Code of Nepal. With the information obtained from the literature review and field visit of labs of various schools, requirements for a STEM lab were identified. A few meetings with experts were organized through which they provided their opinions, experiences and views on topics like floor plans, guidelines required for STEM lab, STEM club formation, monitoring and evaluation of STEM-related activities, etc. Assimilating all the aspects of a STEM lab, a draft master plan was prepared, and discussions were carried out. Ultimately the final master plan was designed to incorporate all the comments and feedback.
The flowchart demonstrates the methodologies during the work.

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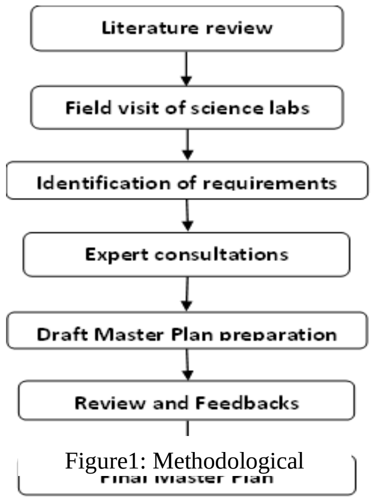

Figure1: Methodological

3. Results and Discussion

3.1 Guidelines for Laboratory Design

This guideline recommends setting up a new STEM lab in a school. *A detailed master plan can be accessed at https://bit.ly/3w8cX0w*

A. Room Requirements

Size

The laboratory should be designed to accommodate 24 students, excluding teachers. The laboratory floor area should be 43 square feet for each student [4]. The minimum standard area should be 1032 sq. ft.

Doors

Each room should have a main entrance and an emergency exit. The doors should have ventilation on their top. The width of the emergency exit should not be less than 3 feet and 6 inches.

Windows

The recommended area of the openings is one-fifth of the floor area for proper natural lighting and ventilation. Windows should be provided on at least two sides of the room for appropriate natural light and ventilation. The sill level should be at least 2 feet 6 inches above the floor level, and the lintel level can be extended up to the beam.

Electricity

Concealed conduit wiring should be hidden inside the wall slots with the help of plastering. A single emergency shut-off switch in each science lab/classroom that will break all the circuits should be provided. The emergency switch shall be highly visible and readily accessible to the teacher but not easily reached by students.

Plumbing

Open the plumbing system on the surface of the wall. CPVC pipes of a half-inch diameter can be used to supply water to each sink, and a one-inch diameter pipe can supply water to the showerhead. There should be two separate gate valves for providing water to the sinks and the showerhead.

Gas supply

Branches from mains to each burner with check valves to prevent the reverse flow.

A. Interior Requirements

Teachers Area

A raised platform should be made that can accommodate a teacher's desk and a chair. At the back, the writing board should be mounted on the wall. The recommended dimension of the teacher's desk is 5'X2'6 "X2'6".

Student's desks and chairs

•Desk

Costume-made wooden desk on wheels, metal framed with waterproof, chemical resistant Phenolic resin laminate top; commonly known as Formica on the market. Each desk should not be designed for more than four students. The following recommendations can be followed:

Table Size: 6'X3'X2'6"'
Edges: Round
Surface finish: Formica laminates (1-1.3mm thick)

•Chair

Costume-made wooden chair with a squared-shaped seat, metal legs, and two spindles (platform to rest legs) at different heights. A hole at the center of the chair is recommended so that it can be lifted, holding from there. Sharp edges should be avoided. The following recommendations can be followed:

Seat size: 14 "X14"
Height: 2'

Storage cabinets

At least four storage cabinets should be provided to store the materials for Physics, Chemistry, Biology, and DIY. The following recommendations are suggested:

Size: 5'X1'6"
Height: Full floor height, i.e., from floor level to ceiling
Material: wood
Opening type: sliding or hinged type with recessed handles
Depth of a shelf: not more than 12 inches
Biology Storage cabinets may incorporate specimen display racks.

Display Cabinets

A display cabinet should be provided to display various items for demonstration.

Exhibition/Writing Boards

Three to four numbers of movable boards should be provided. They can either be used as exhibition boards or as student writing boards.

Flooring

Cement concrete flooring or polyvinyl flooring can be used. The use of floor carpets should be avoided.

Ceiling

In the case of an RCC structure, standard cement concrete painted with suitable color can be used, and in the case of a truss structure, a false ceiling of plywood or Gypsum board can be used.

Paints

Paints that can be wiped clean will not readily absorb liquids and can prevent microbial growth are recommended. Emulsion vinyl paints and acrylic paints can be options [5].

Electricity Fixtures

At least six numbers of electrical outlets should be mounted on the walls. They should be near the students' working table.

Sanitary Fixtures

Single-bowl sinks made of ceramic, steel, or polypropylene is recommended. There should be at least six numbers of sinks for the student. An additional sink may be provided to the teachers. These sinks should be near the students working desks.

Burners

At least six Bunsen burners should be provided for the students. The burners should be placed in such a way that they are near each student's working table. LPG can be used for supplying gas to burners.

Fume hoods

Chemicals with significant inhalation hazards should only be opened inside fume hoods, and experiments generating corrosive and toxic gases should only be performed inside fume hoods. A chemical fume hood with a ducted outlet or an exhaust fan for evacuating the gases accumulated in the hood should be used. There should be the provision of lighting inside the fume hood. A fume hood having storage cabins is recommended.

Preparation Platform

Preparation areas should have enough space for placing different practical equipment. The following recommendations can be followed.

Top width: 2'

Surface finish: Rough Ceramic tiles (50-70mm thick)

Height: 2'7"

Storage cabinets can be placed below the work surface to store chemicals and equipment.

Safety Requirements

Fire Safety

At least two fire extinguishers should be placed at two different locations inside the laboratory. Powder type ABC fire extinguisher is recommended.

Some woolen blankets should be stored so that they can be used for protecting persons during a fire and as fire inhibitors.

Sand should be stored in buckets for metal fire.

First Aid

Each laboratory should have a first aid kit of essential medicines, antiseptic lotions, creams, bandages, sterilized cotton, and Dettol.

Shower and Eye Washes

Each laboratory should have a safety shower to protect persons from chemical splashes and burns and an eyewash to flush away the hazardous substances into the eyes.

They should be within 25 feet of each working area.

There should be the provision of a continuous water supply for at least fifteen minutes once activated.

Waste Boxes

Various categories of waste should be collected in separate boxes.

D. Lab uniform and safety wear

Uniform

Before entering the laboratory, each student should compulsorily wear an apron. Coats and jackets can be hung on the apron hanger placed near entrances.

Safety Wears

While handling hazardous substances, everyone should wear masks, safety glasses, gloves, helmets, and PPEs.

3.2 Sample floor plan

These sample floor plans depict the necessary facility and furniture prepared using AutoCAD software. These floor plans are solely samples, which doesn't mean every design should be exactly similar. A laboratory room is divided into entrance/exit sides, storage/display sides, preparation areas, working areas, emergency treatment areas, teachers' areas, etc.

Figure 2: Sample floor plan-Model 1

Figure 3: Sample floor plan-Model 2

3.3 Materials list

Materials required for conducting curriculum-based science practical and STEM activities are categorized based on science disciplines, availability, reusability, cost, etc. [6]. This section consists of the following materials list: 1. Materials for conducting Physics, Chemistry and Biology experiments. 2. Mathematics materials 3. DIY/STEM materials 4. Materials for low budget 5. Locally available materials 6. Consumable and non-consumable materials. *Detail list of materials can be accessed at https://bit.ly/3w8cX0w*

3.4 Cost Estimate

The table below shows a tentative cost estimate for setting up a school-level STEM lab.

Table 1:Tentative Cost Estimate

Summary of Estimates		
SN	**Expenses Head**	**Amount (NRs)**
1	PCBM (Physics, Chemistry, Biology & Mathematics)	654,880
2	DIY (Do It Yourself)	396,975
3	Furniture	462,000
	Total	**1,513,855**

3.5 STEM Club

STEM club will be formed by the inclusion of students and teachers. The STEM club will help to organize the workshops and carry out activities related to STEM disciplines in order to encourage learning by doing. Consequently, the STEM club fosters technical skills, critical thinking, cooperation, and collaboration among students, which in the long run, will provide students the insights to solve the problems of the community and the nation as a whole.

Table 2: STEM club

STEM Club	
Objective	To promote learning of STEM disciplines in students to make them more marketable.
Club Structure	Three teachers (math, science, and computer) and five students (a student from every class 6-10)
Club Operation	Members visit the lab at least once weekly and use STEM equipment to explore various projects. A workshop to be conducted once a month using STEM equipment

3.6 Teachers Training

The teacher is the prime influencer and decision-maker in the classroom; lack of training, or poor training, will make them face the challenge of having poor subject knowledge and poor professional and pedagogical skills to deliver the lesson, assess learning, and provide the learner with the appropriate knowledge and learning experience [7]. So, teachers' training is necessary to impart effective teaching and classroom management dexterities.

The following table provides succinct information about teachers' training.

Table 3: Teachers' training

Topic	**STEM Lab**
Target Participants	Teachers up to secondary level teaching in Gandaki Province
Training Rationale	Providing knowledge about STEM Lab design and implementation for integration into the current teaching profession
General Objective	To improve teachers' understanding of how to plan, implement and evaluate STEM Lab-related teaching methodologies and bring motivation to enhance teachers' performance and hence students' achievement.
Specific Objectives	• To develop skills and knowledge and implement the framework of STEM education • To learn how to develop and integrate STEM Lab activities into the academic curriculum • To understand different types of STEM Lab activities, and their purpose with examples • To understand different teaching-learning methodologies for STEM education • To cultivate innovative and integrated pedagogy of STEM education in basic education

3.7 Monitoring and evaluation

To be filled before entering the laboratory					*To be filled after exiting the laboratory*			
Date	Entry time	Name of Student/s	Name of Teacher/s	Activity/ Project work	Equipment Used	Challenges	Exit time	Comments /remarks

Figure 4: Sample logbook

For monitoring and evaluation, logbook preparation and evaluation forms are suggested. Monitoring includes the study of how many teachers/students have visited the lab, what they have performed, which discipline is more attractive to the students, how many hours the stem lab was used, and what type of support they need to run the lab smoothly and summarization of all activities that happened in the lab. Figure 4 shows a sample page of the logbook.

4. Conclusions

This comprehensive master plan covers all the aspects required for setting up a complete STEM lab for schools, from the starting phase to the post-monitoring phase. Thus, this document serves as a guide on incorporating and combining multidisciplines to create a platform for learning, innovation, and cooperation, as there is a limited curricular framework for STEM education initiatives in Nepal.

Acknowledgment

We would like to extend sincere thanks to Dr. Shital Babu Acharya, Raj Kumar Dhakal, Er. Hari KC, Dr. Somnath Sapkota, Dr. Kapil Adhikari, Ashish Poudel, Laxmi Kunwar and Pratirakshya Koirala for their guidance, kind support and rewarding suggestions during this study. In addition, we would like to thank the Gandaki Province Ministry of Social Development and Health for supporting the master plan.

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