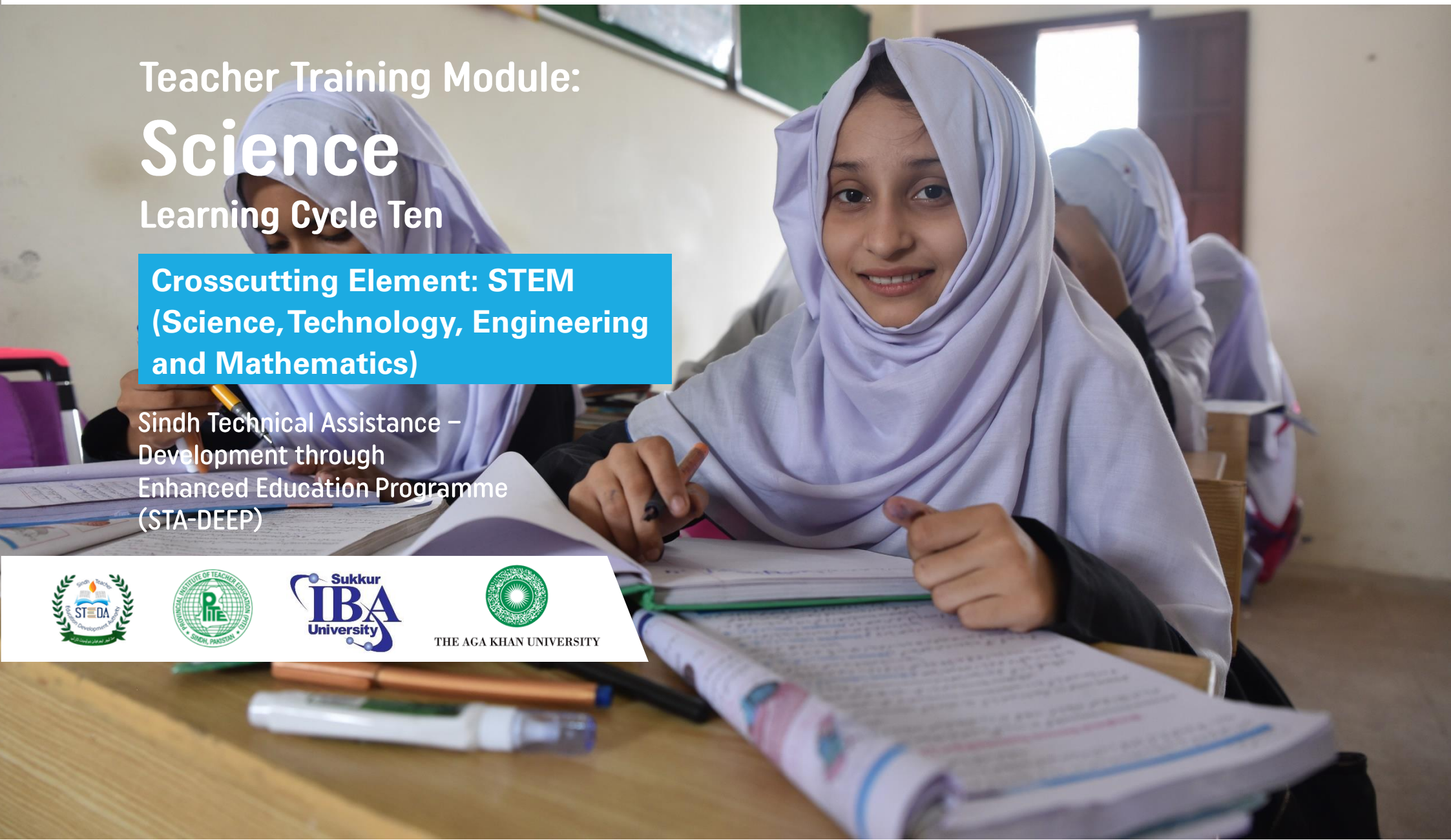
Funded by the European Union

Government of Sindh

unicef for every child



Teacher Training Module:

Science

Learning Cycle Ten

Crosscutting Element: STEM (Science, Technology, Engineering and Mathematics)

Sindh Technical Assistance – Development through Enhanced Education Programme (STA-DEEP)

STEDA · PITE Sindh · Sukkur IBA University · The Aga Khan University

Introduction and Rationale of the Training

Dear Teachers!

Welcome to the new phase of the Continuous Professional Development (CPD) Program. In the previous phase, we had focused on pedagogical skills that helped you to develop your skills to make classroom more interactive, participative, and joyful for our students. In the new phase, we will continue practicing those pedagogical skills and also learn about the introduced content knowledge and skills in Mathematics, Science, English, Urdu, and Sindhi. As a result, you will be better prepared to deal classroom situation using modern teaching strategies integrated with subject knowledge.

Our vision

Our common goal is to improve the quality of teaching in schools all over Sindh. We want students to become active and collaborative learners, problem solvers, and critical thinkers who approach tasks with creativity and confidence. They are conceptually clear about the subject content and have the skills to link this content with the world around them. To make this possible, we, as teachers, must be better prepared for the classroom demands in pedagogy and the subject content. Moreover, we aim to professionalize these trainings so that the CPD teacher training courses make an impact and substantially change student performance.

Our Teaching Philosophy

The CPD training sessions, including this training, follow a participatory teaching philosophy that engages participants to apply and practice active and collaborative learning, as well as engage in self and peer reflection to become community of practice. The objective is not only to improve the teaching practices but to help you understand the theory of the subject content and the strategies that help students apply the content in daily life with confidence and mastery.

Supporting You

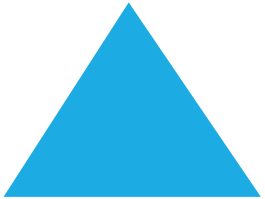
The training module is designed to support you in your classroom teaching. It will introduce you to the subject content and some approaches for use in the classroom. This will make your teaching more manageable and help you grow as a skillful teacher.

Acknowledgement

This module was developed by IBA Sukkur University and Aga Khan University - Institute for Educational Development under the direction of the Provincial Institute of Teacher Education (PITE). It was supported by UNICEF in the scope of the Sindh Technical Assistance Development through Enhanced Education Program (STA-DEEP), funded by the European Union.

We would like to express sincere gratitude to the following contributors:

Sayed Rasool Bux Shah	Executive Director, Sindh Teachers Education Development Authority (STEDA)
Nusrat Fatima Kalhoro	Director-General Provincial Institute of Teacher Education (PITE)
Tikam Herchandani	Additional Director, Directorate of Teacher Training Institutions Sindh, Hyderabad
Dr. Altaf Hussain Samo	Director Executive Development Center at Sukkur IBA University
Dr. Takbir Ali	Associate Professor and Director Outreach at Agha Khan University Karachi
Zaheer Abbas Chang	Director Provincial Institute of Teacher Education (PITE)
Rasheed Ahmed Channa	Deputy. Director, (STEDA)
Tehseen Zehra	Associate Professor, GECE Qasimabad, Karachi
Imtiaz Ali Kumbhar	Assistant Professor, GECE Qasimabad, Karachi
Dr. Tasneem Anwar	Module Developer, Agha Khan University (IED), Karachi
Jamila Khanum	Module Developer, Agha Khan University (IED), Karachi
Arslan Ahmed	Module Designer, Sukkur IBA University
Abdul Jabbar Shah	Module Designer, Sukkur IBA University
Syed Kamran Shah	Project Manager, Sukkur IBA University
Rabia Batool	Project Manager, Sukkur IBA University
Asif Abrar	Education Specialist, UNICEF
Dr. Salima Begum	Education Officer, UNICEF
Muhammad Zulfiqar Ali	Education Consultant, UNICEF
Aftab Ahmed Nizamani	School Clustering Consultant, UNICEF

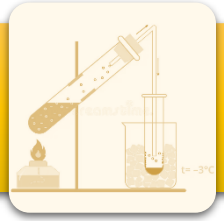


Crosscutting Element: STEM (Science, Technology, Engineering and Mathematics)

Learning Objectives: By the end of the session, the teachers will be able to:

Unpack STEM and visualize it in the science National Curriculum Paksitan (NCP, 2023)

Practice STEM to see its core elements in action



Apply STEM learning to plan for classroom implementation of crosscutting elements while science teaching as given in the NCP, 2023

Session Plan

Instructional strategies/activities

Time	Objective/purpose of the activity	Activities/learning experiences	Materials/resources
15 mins	**Welcome** Introductions – facilitator and teachers 	1. Ask the teachers to do a speed round of sharing their best learning from LC 1-9. 2. Create ground rules for the teamwork and communication that are necessary for STEM teaching and learning.	Sticky notes
15 mins	**Warm up** Facilitator will connect teachers to the core concept 'STEM' *(Science, Technology, Engineering and Mathematics)* through this task.	1. Facilitator will ask teachers to visually represent what do they mean/understand by STEM on the given sticky note. 2. Then, the facilitator will re-group the sticky notes to summarize how do teachers perceive 'STEM'.	Sticky notes

<table>
<tr>
<td> 
30 mins</td>
<td>Input
Hands on experience of STEM learning</td>
<td>
1. In group of 3-5 persons, teachers will be given ‘Cotton Ball Challenge’ to solve (see Handout 1).
2. Teachers will be provided with the criteria (see Handout 2).
3. They will also be briefed about the real-life constraints and given a packet of limited materials to model those constraints (see Handout 3).
Teachers will solve the challenge in the given 12 minutes.
4. At the end of 12 minutes, each group will record the data in the given table to determine which group/s have been able to successfully respond to the challenge:

<table>
<tr><td>Group➔</td><td>Group 1</td><td>Group 2</td><td>Group 3</td><td>Group 4</td></tr>
<tr><td>Height➔</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Free-standing Structure➔</td><td>Yes/No</td><td>Yes/No</td><td>Yes/No</td><td>Yes/No</td></tr>
</table>

1. Facilitator Input: After engaging in the ‘Cotton Ball Challenge’ facilitator will ask the following questions:
a. Where you able to apply the science and or mathematics to solve the given problem
b. Was the problem relatable?
</td>
<td>Broomsticks, cotton balls, string, masking tape, ruler, pair of scissors.</td>
</tr>
</table>

		c. How did you find working in a group? d. Did you make a plan? Were you able to try out your plan? e. Did you test your plan? f. Were you able to learn from the test of your design and make some changes/improvements in your prototype (an early sample or model of a product built to test a concept or process)? **2.** After listing the answers of groups on the board, the facilitator will provide input on the following using the Handout 4*: **a.** What is STEM? **b.** Core elements of STEM **c.** Steps for planning STEM *Anwar, T., Siddiqi, U. (2023). Transfer of STEM Research for Designing Contextually Relevant Curriculum in Pakistan: A Case Study. In: Spector, M.J., Lockee, B.B., Childress, M.D. (eds) Learning, Design, and Technology. Springer, Cham. https://doi.org/10.1007/978-3-319-17727-4_190-2	
10 mins	**TEA BREAK**		
30 mins	**Practice** Teachers will use the 'Make it STEM' template to add the core elements of	1. All groups will be asked to use the 'Make it STEM' template to deconstruct the 'Cotton Ball Challenge' and add the core elements of STEM (see Handout 5). 2. This will allow teachers to see the details of STEM. Afterwards, facilitator will provide each group with a 'Make-it STEM' template and ask each group to design a STEM unit draft based on the assigned	Materials to carryout scientific inquiry (Handout 3)

<table>
<tr>
<td></td>
<td>STEM for the ‘Cotton Ball Challenge’

Each group will present their STEM unit draft (20 min) followed by facilitator input (20 min).</td>
<td>science concept. They will also be encouraged to plan about potential materials that will be used.

a. Group 1 will be assigned the concept of ‘Forces’ from grades 4 and 5.
b. Group 2 will be assigned the concept of ‘Light’ from grade 6. Group 3 will be assigned ‘Chemical Reactions’ from grade 7.
c. Group 4 will be assigned ‘Heat Energy’ from grade 8.</td>
<td></td>
</tr>
<tr>
<td> 
40 mins</td>
<td>Input</td>
<td>1. Facilitator Input on teachers group Presentation: Facilitator will debrief on the various ways of designing the STEM unit plans that are done in four groups and help the teachers connect it with the core elements of STEM and NCP, 2023 p.1-2 (science grades 4-8):

<table>
<tr><th colspan="2">Thinking and Working Scientifically
Overarching SLOs that will be addressed during the course of teaching different scientific concepts.</th></tr>
<tr><th>By the end of Grade 5 students should be able to:</th><th>By the end of Grade 8 students should be able to:</th></tr>
<tr><td>Scientific Enquiry:
• Ask questions
• Know the five main types of scientific enquiry (observe over time, identify and classify, compare and contrast, fair test, research-by finding information).
• Use equipment to carry out scientific investigations.
• Take measurements and record them.
• Enlist and practice safety procedures while carrying out practical activities.
• Make a conclusion from results informed by reasoning.</td><td>Scientific Enquiry:
• Identify whether a given hypothesis is testable.
• Make predictions of likely outcomes for a scientific enquiry.
• Plan a range of scientific investigations e.g. observe and classify etc.
• Know the meaning of hazard symbols, and consider them when planning practical work.
• Decide what equipment is required to carry out an investigation .
• Take precise measurements, explaining why accuracy and precision are important.
• Collect and record observations and/or measurements
• Describe trends and patterns in results.
• Make conclusions by interpreting results informed by reasoning.
• Suggest improvements while doing experiments.</td></tr>
</table>
</td>
<td></td>
</tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td>
<table>
<tr>
<td>Engineering Design Process - STEM/ STEAM

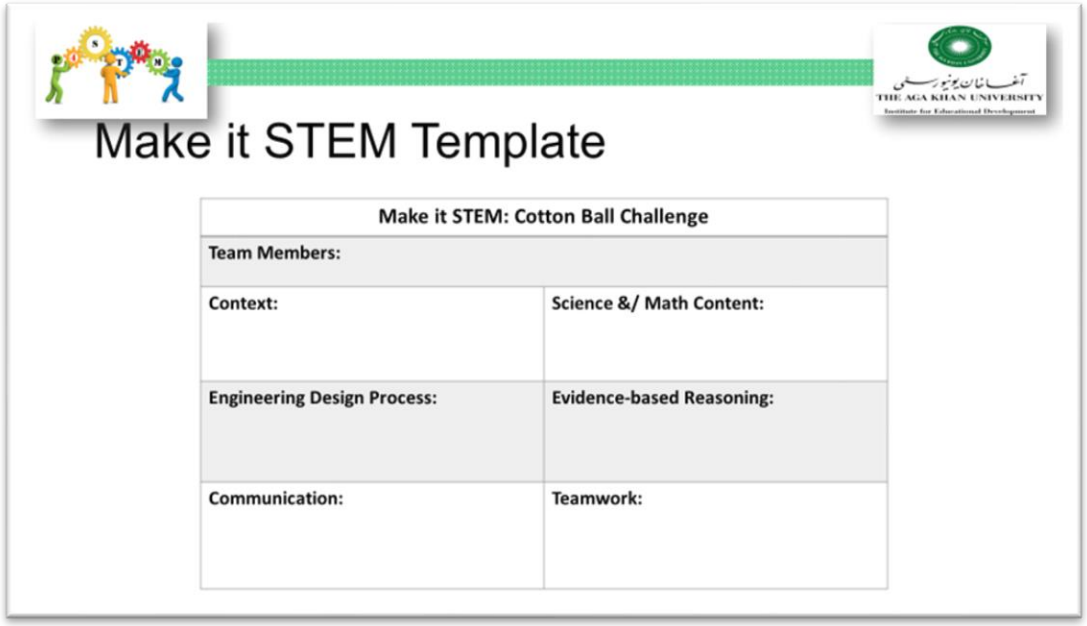
Models and Representations
• Use models to show scientific ideas and what happens in science.
• Use a variety of technologies following the design process to identify and solve problems, to interpret data and present the data collected in the form of graphs and charts.</td>
<td>Engineering Design Process - STEM/ STEAM

Models and Representations
• Describe the strengths and limitations of a model.
• Use symbols and formulae to represent scientific ideas.
• Use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions to challenges/ enquiry questions.
• Apply mathematical concepts (e.g., percentages and ratios) to analyze data and present the data collected in the form of graphs, charts and tables.</td>
</tr>
<tr>
<td>Science in Context:
• Describe how science is used in their local area.
• Identify people who use science, including professionally, in their area and describe how they use science.
• Discuss how the use of science and technology can have positive and negative environmental effects locally and globally.</td>
<td>Science in Context:
• Describe how science is applied across societies and industries, and in research.
• Discuss issues which involve and/or require scientific understanding.
• Describe how people develop and use scientific understanding.
• Discuss how the uses of science can have a global environmental impact.</td>
</tr>
</table>
</td>
<td></td>
</tr>
<tr>
<td> 
30 mins</td>
<td>Reflection for Action
This will allow the teachers to apply their learning of the workshop and create a plan for their classrooms.

Individual Task- STEM plan for classroom implementation</td>
<td>1. Facilitator will ask teachers to recall all the STEM ideas discussed during this session and identify what would best align with the grade level they are teaching at.

2. Facilitator will encourage the teachers to try out the STEM ideas discussed in the session.

3. Facilitator will ask each teacher to identify the content/level by referring to the curriculum/textbook and pick a problem from the relatable context to make a plan for implementing STEM in their classroom by filling in the ‘Make it STEM’ template.</td>
<td>Make it STEM template for each participant.</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td> 
</td>
<td></td>
</tr>
<tr>
<td> 
</td>
<td>Consolidation
To reflect on their learning and recap the key takeaways from the workshop.</td>
<td>Mightiest and Muddiest Point
a. Use ‘Mightiest and Muddiest Point’ strategy for the conclusion. It is an assessment strategy used here to know how have teachers responded to this session on the crosscutting elements in particularly STEM. They will reflect on the session and respond with one key learning (mightiest point) and one area that remained confusing/fussy (muddiest point).
b. Give the participants sticky notes/paper chits and ask them to record as follows:</td>
<td>Sticky notes/paper chits</td>
</tr>
</table>

What was your mightiest point today?

What was your muddiest point today?

---

c. Facilitator will take a few responses to conclude the session and collect the notes at the end to get feedback on the overall session.

آغا خان یونیورسٹی
THE AGA KHAN UNIVERSITY
Institute for Educational Development

Cotton Ball Challenge

Problem from local context:

The Karachi City Government wants to compensate for the forced evictions that took place for the completion of Lyari Expressway project. They want to build tall towers (buildings) to accommodate the many affected families by using minimal land. They have approached our **Participant Teams** to brainstorm the most efficient and effective way to build a tower.

آغا خان یونیورسٹی
THE AGA KHAN UNIVERSITY
Institute for Educational Development

Cotton Ball Challenge

- Build the **tallest freestanding** structure.
- The **entire cotton ball** has to be on the top.
- **Use** as much or as little of **the kit**.
- **Break up** the broom sticks, string or tape.

ATTENTION

1. Define & Learn about your problem
2. Plan & Try solution
3. Test your solution
4. Decide after re-design

آغا خان یونیورسٹی
THE AGA KHAN UNIVERSITY
Institute for Educational Development

Cotton Ball Challenge

Build the tallest freestanding structure

Teams of three/four people

3 + 9 minutes

Using the following ingredients:

- One cotton ball
- One yard string
- One yard masking tape
- 20 broom sticks of 1 foot each

STEM Integration Framework for Science Teachers

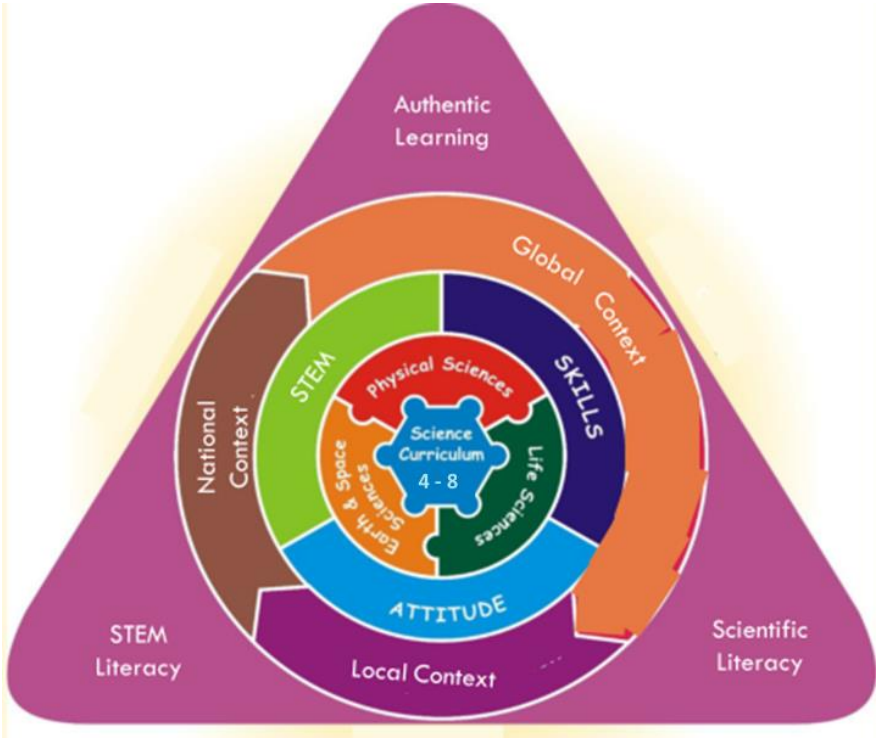


Figure 1. Science curriculum framework

The Science curriculum framework (figure 1) visually represents central role of three science content strands and the three cross cutting elements that are embedded within the local, national and global contexts to offer students opportunities of authentic learning to develop scientific and STEM literacies.

After visualizing the place of STEM within science curriculum, it is important to understand how STEM will look in action when taken into the classrooms. STEM lessons will demonstrate integration of disciplines by purposefully situating the Science and Mathematics content strands in the local, national and global context. Engineering Design Process (EDP) will allow the integration of disciplinary connection while solving contextual real-world problems. Here, it is important to note that unlike the case in the developed parts of world where Engineering is offered as a discipline or is a part of school curriculum, in Pakistan, Engineering is a new idea at school level. Therefore, it is important to recognize this fact and then take a start in this direction by just adopting the EDP as an integrator of the remaining disciplines. The EDP will allow students to experience how engineers work.

The EDP is a systematic and iterative process in which student teams will first **define** and **learn** about the problem/STEM challenge posed by the client with specific set of constraints. Later, EDP (figure 2) will involve student teams in **plan**ning, **try**ing, **test**ing, and **decid**ing the best solution - which is usually a technology, to communicate to the client while highlighting how have they satisfied the set of constraints defined by the client and satisfying the end users' needs too. The entire EDP engages students in **teamwork** and **communication**. In short, as represented in Figure 3, when students are engaged in a purposefully designed STEM experience, the explicit science and mathematics SLOs that are used to solve the STEM challenge arising from the real-world context using the EDP,

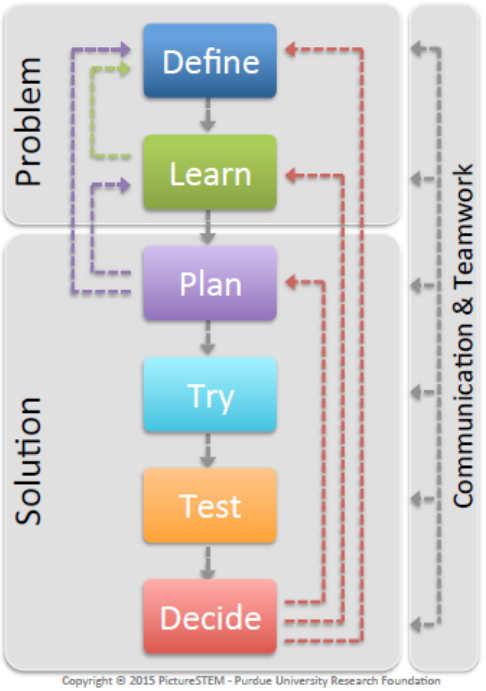
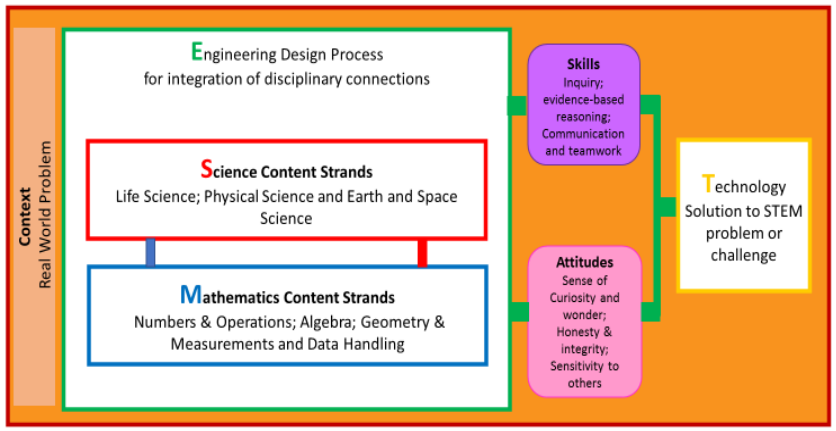


Figure 2. Engineering Design Process

students come up with a technology solution which allows opportunities to employ skills (inquiry, evidence-based reasoning, creativity, communication and teamwork) and demonstrates attitudes (sense of wonder, honesty and integrity, sensitivity to others).



The STEM integration framework presents the six important elements for taking STEM into classrooms:

1) Context and the Problem
2) Science and Mathematics Content
3) The Engineering Design Process (EDP)
4) Evidence-based Reasoning
5) Communication and
6) Teamwork

Figure 3. STEM integration framework for Action in Classrooms*

*Anwar, T., Siddiqi, U. (2023). Transfer of STEM Research for Designing Contextually Relevant Curriculum in Pakistan: A Case Study. In: Spector, M.J., Lockee, B.B., Childress, M.D. (eds) Learning, Design, and Technology. Springer, Cham. https://doi.org/10.1007/978-3-319-17727-4_190-2

Steps for Planning STEM

STEP 1

Build a team of teachers preferably science, and mathematics.

STEP 2

Teacher teams will look for the specific SLOs from Science as a starting point and take a problem from local/national/global context and create an authentic STEM challenge. This STEM challenge will require:

a. a problem posed by a client,
b. well-defined criteria and constraints of the posed challenge,
c. a need for engaging in 'Engineering Design Process'
d. specific science and mathematics SLOs.
e. a prototype- a technology that will be an open-ended solution to the posed STEM challenge.

Note: *Teacher teams can also start with a problem from context and the STEM challenge. Afterwards, they could decide what specific science and mathematics SLOs are needed to solve this real-world authentic problem.*

STEP 3

Teacher teams will plan for the learning and assessment tasks that would focus at the specified SLOs. While 'Teamwork and communication' will also allow for the assessment of skills (4Cs) and attitudes. Rubrics can guide both teachers and students in reaching to the expected SLOs.

STEP 4

Teacher teams need to do a thorough planning for materials that are contextually relatable, easily available, and most importantly low cost.

STEP 5

Teacher teams will need to prepare lesson plans for the STEM unit that will engage students in:

a. exploring and learning about the real-world problem and relevant data,
b. the science and mathematics needed to solve the posed problem/STEM challenge
c. the Engineering Design Process for the application of STEM
d. making decisions for choosing the suitable materials for planning and designing their prototype.

Note: *The above numbering does not bind teacher to follow it in the given order. They may start with the science content lessons first and so on.*

آغا خان یونیورسٹی
THE AGA KHAN UNIVERSITY
Institute for Educational Development

Make it STEM Template

Make it STEM: Cotton Ball Challenge	
Team Members:	
Context:	**Science &/ Math Content:**
Engineering Design Process:	**Evidence-based Reasoning:**
Communication:	**Teamwork:**

Additional Resources

https://www.teachengineering.org/curricularunits/view/cub_simp_machines_curricularunit

https://www.teachengineering.org/curricularunits/view/cub_soundandlight_curricularunit

https://www.teachengineering.org/lessons/view/ucd_heat_lesson01

https://www.qcaa.qld.edu.au/downloads/aciq/stem-resources/teaching/ac_stem_designing_unit.pdf

https://www.stem.org.uk/resources/community/collection/495112/units

https://dloft.stanford.edu/resources/dloft-curriculum-units