Oh! I never knew Biro invented the ballpoint pen.

My little brother is crying. Can I make a new toy for him using something available at home?

INVENTOR’S WORKBOOK

SCAMPER
SUBSTITUTE
COMBINE
ADOPT
MAX/MIN/MODIFY
PUT TO USE
ELIMINATE
REVERSE

Mom, my bag is worn out. What will I do for tomorrow?

Oh my son why don’t we prepare a bag ourselves using locally available material.
Team name:

Team members:
**About the ‘Inventor’s Workbook’**

This workbook is the first draft developed for the ‘Invention Education’ programme initiated by SELCO Foundation to inspire students to be more innovative and creative. The workbook contains stories on invention and various hands-on activities that help children apply their knowledge on design, sustainability and scientific concepts to develop innovative solutions to local problems or needs.

**About the ‘Invention Education’ programme**

Invention Education programme, an initiative by SELCO Foundation funded by the Lemelson Foundation and supported by Rotary Club Belthangady and Sir Ratan Tata Trust aims to empower children to apply science and innovation to strengthen the life of rural communities. The ‘Invention Education’ program intervenes in low resource government schools in rural areas on a continuous basis to introduce hands on activities, set off the spark for innovation and equip children with the necessary skills to do the assessment of their community – their needs, issues and come up with issues that they want to work on and mentor them to build innovative solutions for these issues.
Acknowledgements

This book has been possible because of our team and each one of them have played a crucial role from it’s inception. Thanks to the vision and ideation provided by Dr. Anand Narayan and Ashwathi Iyer’s efforts on conceptualizing and putting together the content. I would like to thank Kishore Kumar, who helped us with the translation of the content into Kannada without which we couldn’t have reached the 500 government school children very effectively.

I would like to thank our team of facilitators Nishkala K R, Naveen Kumar, Mamthaz, Sushmitha V, and Yallamma H. who put in efforts to bring the book to this state and who are crucial in the delivery of the content effectively in the schools. Thanks to the efforts of Lavanya Murali and Sushmitha V on illustrations that has made the book colourful and lively. I hope children will enjoy them. Also thanks to David Coronado, who sent the content developed by OreganMESA and we could effectively modify it to suit the local scenario.

I would like to thank P P Joy, a very enthusiastic science teacher who reviewed our content in Kannada and all my colleagues who gave their valuable feedback and suggestions. Finally I would like to thank folks at Lemelson Foundation who have played a vital role in the initiative and funded us, also Rotary Club Belthangady and Sir Ratan Tata Trust for partnering with us on the programme and providing the necessary financial and moral support.

Deepti R Bhat
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INVENTOR STORIES
BALL POINT PEN

WHY BALL POINT PEN?

When there is an urgent need or when something is extremely difficult, we come up with interesting solutions to that problem. The story of the ballpoint pen is also similar.

BEFORE THE BALL POINT PEN

Before the ballpoint pen or the refill pen was created, only the fountain pen existed. In this pen the ink had to be filled every time it got over.

Do you think it was too cumbersome to fill the ink every-time it got over? Read ahead to know what prompted the invention of ballpoint pen.
Year: 1938. There was a journalist called Laszlo Biro who worked for a newspaper in Hungary. Do you know where Hungary is? Can you spot Hungary in the map given below?
Now imagine Biro sitting on his table trying to write with his fountain pen and the ink blotting on the paper. He complains about this problem every time he writes and doesn't really do anything to solve this issue. Do you think you would be holding a ballpoint pen in your hand now?

WHAT WAS THE PROBLEM?
Biro was frustrated with ink leaking from the fountain pen constantly. When he wrote there were several smudges and blots. He noticed that the ink used for printing dried up quickly. He tried using it in a pen. But this ink was too thick and did not flow. What did he do to solve this problem?

THE SOLUTION!!
So with his brother's help he devised a pen with a ball at the nib. As a solution he thought of closing the end of the pen instead of using a nib, leaving an opening with just enough room for a tiny metal ball that would spin against the ink and distributing it to the paper.

Later a British company took over the patent and started producing the pens.

Even before Biro there have been several similar attempts by others to solve various problems in using fountain pens.
MOBILE PHONE

THE MOBILE MAGIC!

Telephone calls earlier could only be made to a house or a particular place where a person is expected to be. Now calls can be made to a person or an individual anytime and from anywhere and no matter whether the receiver is at home/office or travelling. How and when did this change come about? When you go alone or if there is something urgent to convey, you immediately call the person over the mobile phone.
WHY IS IT CALLED THE ‘MOBILE PHONE’?

‘Mobile’ means something that can be moved easily from one place to another. The name mobile phone has been given because the phone can be taken or moved to any place. It is also a ‘wireless’ technology because there are no wires that connect the device anywhere.

WHOSE IDEA WAS IT?

HOW DID THE IDEA ORIGINATED?

‘Martin Cooper is considered to be the 'father of cell phone.' He was an engineer and working for the company Motorola in the US and here he tried developing many products.

Before the mobile phone, Martin's competitor company had developed a technology called Cellular. Cellular was a phone to make calls from the car. This gave Martin and Motorola the idea that what people needed was personal phones that could be carried by people anywhere, even outside the car.
In around 1973 Martin envisaged the hand-held phone. He was inspired by a device that used to be shown in the TV series Star Trek. He said that a number should be assigned to a person, not a place or a desk or a house. It took 10 years for the product to become available in the market.

The phone had certain cells that could transmit and receive signals for communication. The first model of mobile phone was very big and heavy. The prototype handheld phone used by Dr. Cooper weighed 1.1 kg and measured 23 cm long, 13 cm deep and 4.45 cm wide. The prototype had a big battery, offered a talk time of just 30 minutes and took 10 hours to recharge.

In 1973, when Martin Cooper first wanted to demonstrate the phone to the public he made a call from his hotel. As reporters and media watched, he made a call to the landline number of his chief competitors Joel and said, "This is Marty. I'm calling you from a cell phone, a real handheld portable cell phone."

The mobile phone was extremely expensive when it was first made. Even Martin did not think that it would be available to almost everyone. And now after 40 years almost everyone would have used a mobile phone at least once.

**THE LITTLE INVENTOR MARTIN**

“I’d been taking things apart and inventing things since I was a little kid .... I still have memories as a child trying to really understand how things work.”
Have we all seen safety pins? Have we all used it sometime or the other? Can you think when and for what all purposes you have used it? Who thought of twisting a pin in such a way that it has become so important to us today?

It was someone called Walter Hunt. He used to live in New York, which is in USA.
THE STORY OF SAFETY PIN

This happened in 1849. Can you imagine how many years back this story happened?
Walter Hunt was not rich. He had taken a debt of 15$ from his friend and was worried about how he could pay it back.
One afternoon he was sitting on his desk thinking for a long time. He was holding a piece of wire which he was twisting and bending. After three hours he saw what he had made of it. The wire had a spring-like coil where it could turn and one end had a clasp. The clasp helped put the sharp end of the wire in.
Once he realized that it could be useful he filed a patent. In the papers he mentions that it can be used for inserting into the dress without causing any wound to the user.

He got money for his patent and used it to pay his friend the 15$ debt. Walter has also invented the sewing machine and other things that we still use. How a small object has become popular and used by everyone every day!

Can we now try and tell this story to others in the school through a drama? One person can be Walter and another, the friend. Create some interesting dialogues to act out the incidents that led to the invention of the safety pin.
MOSQUITO REPELLENT

What is Arecanut used for? We know that it is mainly used in *paan* (betel) to chew. But did it occur to you that it could be used to produce other things as well.

ABOUT DAYANAND

Let us read about Dayanand Patwardhan who lives in small town near to ujire in Dhakshina Kannada district in Karnataka. He is 60 years old. He has been growing and selling arecanut for the past 35 years. He thinks that arecanut can be used in many interesting ways.
HIS EXPERIMENTS WITH ARECANUT

For the business, arecanut is sliced before being sold in shops. Dayanandh has a big machine to slice the nuts. When arecanut is sliced, it leaves a lot of powder that is thrown away.

Eight years ago, Dayanandh started thinking about what can be done with this powder instead of throwing it away. After working with the arecanut for so many years he knows that it contains the chemicals alkaloid, arecoline and so on. Alkaloid can cause mosquitoes to become inactive. This gave him the idea of making a mosquito repellent with arecanut in it. He powdered the coarse residue into fine powder. Then he began trying out various experiments with this powder.
He soon found out that this powder was not burning properly. To solve this problem he made a mixture of 50% of this areca nut powder, 40% of cow dung and the rest was cow urine. He used a mixer to make this mixture.

He was then trying to decide what shape the mosquito repellent would be. He thought of making it like a cone, or a round shape and even a square shape. Then he saw the ‘shyavige’ (‘semige’ in tulu)-producing machine and got an idea from that. He made a machine that worked the same way but made rod-shaped repellants.

Did you notice, Dayanad used his keen observation skills and kept searching for ways to utilize the areca nut powder? Also he never stopped when he found out that the powder couldn’t burn. He kept thinking about ways to come up with the solutions. What do we learn from his approach to solve the issue?
He gave this to different people-- his neighbors, friends, doctors and scientists to be used and to test the effects. They used it and told him whether it really helped drive away mosquitoes. "The doctors told me this was better than the regular mosquito repellent that had chemicals. Even children did not have any breathing problems caused by the fumes," says Dayanandh. Scientists have approved of his repellent and it is being exported to different countries, such as Africa.

Dayanand is continuing his research. He is now researching on new ideas, trying to see what other new products can be produced using areca nut.

**HIS MESSAGE TO YOU....**

"To survive you have to research on something all the time."
DESIGN YOUR OWN EXPERIMENT!

Time needed: 3 days (3 sessions)

LEARNING OBJECTIVES

• To design experiments in order to test simple scientific statements
• To understand:
  - Experimental design
  - Usefulness of approximations
  - Experimental errors
  - How to debug an experimental setup
• To identify interconnectedness between science concepts

WHY?

In this activity, you will design experiments to test a simple scientific fact. It will help you apply the science concepts you learnt in the previous phase to a hands-on problem. In addition to achieving the learning objectives listed above, this activity will act as a bridge between critical thinking in the context of science and engineering and critical thinking in the context of invention and innovation.
Activity 1:

**WHY SHOULD WE EXPERIMENT?**

It is very important to design one’s own experiments. Experimental design is the starting point for scientists and engineers who want to invent or innovate. For instance, if you want to come up with a better organic fertilizer, you have to experiment with different candidate chemicals to determine the best fit.

**FEW REASONS WHY WE SHOULD EXPERIMENT NOW!!**

Now, how many of you take every day scientific facts for granted? A good way to practice experimental design is to start by designing experiments to test simple scientific statements that we hear about every day. Doing this will help you understand several things like approximation, experimental errors, control variables etc. In this activity, you will be doing just that!

Just so you get a better idea about how to go about designing an experiment, the facilitator will do a demonstration for you to test the following fact: **The air we exhale has lower oxygen content than the air we inhale.** How do you think this fact can be tested or verified?
**Hints:**

1. How would you normally test if there is a lower concentration of something (for example, if there are two glasses of water with different concentrations of sugar, how will you determine which glass has more sugar)? Can you do something similar in this case?

2. To test for a difference in the concentration of oxygen, can we use a property of oxygen?

3. What property of oxygen can you use? One idea is to use the fact that oxygen is needed for things to burn.

**DEMONSTRATION**

**Things needed:**

1. Two candles
2. Two transparent glasses
3. Straws
4. Play dough

**Instructions:**

1. Light the two candles and cover them with one inverted glass each
2. Insert a straw inside each of the glasses from underneath, so that a part of it is sticking outside
3. You will be blowing in your exhaled air through one of the straws
4. Is it necessary to ensure that no air leaks out in this process? How can you do this?
5. Use the play dough to block any gaps through which air can leak out
6. Keep exhaling air through one of the straws until the candle in this glass gets extinguished
Note: One principle can be proved using different methods.

Carbon di oxide turns lime water milky. We can use this fact to prove above principle.

Do the following.

DEMOSRATION

Things needed:

1. Lime water
2. 2 beakers
3. 2 straws

Instructions:

1. Take lime water in both the beakers.
2. Insert straws in both beakers.
3. Keep one of the straws as it is in the beaker.
4. Now keep exhaling air throw lime water using straw in another beaker.
5. Observe the changes in both beakers. What you will decide?
Notes on the Demonstration

• When you keep exhaling through the straw, you are increasing the concentration of carbon dioxide in the air inside that glass. Carbon dioxide is heavier than oxygen, so the carbon dioxide should sink to the bottom, closer to the candle flame, cutting out oxygen supply to the wick.

• Remember that the oxygen in each glass is being used up by the burning candle wick. But for the glass that you are NOT exhaling into, the oxygen is replenished— as the oxygen in this glass is used up, the air pressure inside the glass decreases, and this causes air from the atmosphere to be sucked into the glass through the straw. But this isn’t the case with the glass that you are exhaling into.

• This is why the candle in the glass that you are exhaling into will burn for a lesser time.

• What is a practical application of the fact that carbon dioxide can be used to extinguish flames?

• In the second method, lime water reacts with carbon dioxide to give calcium carbonate and water. The solution becomes milky and confirms the formation of calcium carbonate.
You should have a fair idea about how to design your own experiments now.

### LET'S DESIGN AN EXPERIMENT!!

Choose ONE of the following scientific statements and design an experiment to test it.

1. Mammals huddle to conserve heat
2. Citrus peels can kill mosquito larvae
3. It is safe to water plants with grey water
4. Soil affects the pH of water that it is in contact with.

---

After you have picked your choice, brainstorm with your group members about how you will approach the design problem. Write your ideas in the Brainstorming Sheet. Good luck!
Hints for the Brainstorming Session

The point of this exercise is to give you an opportunity to design an experiment and not to get the “right answer.”

There are several possible designs, some of which, even the facilitators wouldn’t have foreseen! However, if you are having a lot of trouble coming up with ideas, below are some pointers to help you out:

a) Mammals huddle to conserve heat – You can design an experiment by pouring hot water in several paper cups and arranging them in a flower-like circular pattern with one cup in the center. Then, you can monitor how the temperature of the water in these cups decreases. The control can be a set of cups placed far away from each other.

b) Citrus peels can kill mosquito larvae – Find water bodies with mosquito larvae and put lemon peels in the water.

c) It is safe to use grey water to water the plants – Use grey water from your houses and monitor the growth of a fast-growing plant like radish or fenugreek.

d) Soil affects the pH of water it is in contact with – Collect water from different places and correlates the pH of the soil in that region with the water collected.
1. Activity leader:

2. You will work on (circle your choice):

   • Mammals huddle to conserve heat
   • Citrus peels can kill mosquito larvae
   • It is safe to use grey water to water plants
   • Soil affects the pH of water that it is in contact with

3. Should you measure a variable in order to test this statement? If yes, name the variable.

Now, discuss with your team members how you will design the experiment. Some things to consider are:

When designing an experiment, it is always helpful to have a control system and system that you will be varying a parameter in. You should measure or study the same variable in both systems.

For example, when designing the experiment done as a demonstration, there were two systems – one that you were exhaling into and one that you weren’t exhaling into (the control system).
<table>
<thead>
<tr>
<th>Materials required</th>
<th>who is responsible?</th>
<th>Is it recyclable?</th>
<th>Is it toxic?</th>
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Typically, most of the materials you use in your design should be cheaply or locally available. Why?

4. Briefly describe or draw your experimental setup.
5. Will your experiment cause pollution (air, water, noise)?

Check if you have all the necessary materials to start your design. Use the Design Analysis Sheet to guide you while designing the experiment.

At the end of the activity, please fill the Self-Reflection Sheet so that you can see if you enjoyed working in a team.

Remember: Don’t get disheartened if your experiments don’t work! Sometimes, it takes months or years to get an experiment to work properly. And sometimes, the experiments you design might need more than 3 days to give conclusive results. That’s fine too!
DESIGN ANALYSIS SHEET

1. Activity leader:

2. Materials checklist (list all the required materials and put a tick mark next to the ones that you have):

3. Draw your experimental setup & label each part.
4. In the last phase, you learnt how to record your observations and inferences. You should do the same for this experiment, but you have to figure out what to observe and infer. Things to consider:
- What are the different parameter affecting the experiment.

- Are you measuring a variable? Are you studying a variable? How do your observations of this variable change as your vary the parameter?

After you have built your setup & ensured that it is working properly, answer the following questions.

5. What are the sources of error?

Additionally, if you run into any problems while designing the experiment (something doesn’t work, something broke, you
realize you need more materials), briefly note them down in your journal.

Lastly, you should think of how to connect this experiment to sustainability. If you are unsure of what sustainability means, consider if you’re learning from this experiment can help you do one of the following:

- Save energy
- Reduce pollution
- Conserve natural resources like water and biodiversity
- Identify ways in which natural resources are polluted by human practices
- Create an income-generating opportunity that doesn’t negatively impact the environment
SELF-REFLECTION SHEET

1. Name –

2. My biggest contribution to the team was…..

3. I could have been more helpful if……

4. My team members worked well together because....

5. My team faced the following challenges:

6. I tried to overcome these challenges by....

7. If I had to rate my contributions to the team, I would give myself a .......... out of 10.

8. If I had to rate my team members, I would give:

<table>
<thead>
<tr>
<th>Name of team member</th>
<th>Score out of 10</th>
<th>Reason</th>
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SCAMPER

Time needed: 2 hours (2 sessions)

LEARNING OBJECTIVES

- To brainstorm in a systematic manner
- To make design blueprints on paper
- To think about ways in which existing designs can be improved

WHY?

SCAMPER is an acronym for a list of words that will help you approach a design problem in different ways. It provides a framework for brainstorming, which is the first step of a design process. Though you are already familiar with the brainstorming process, this activity will help you get better at it by giving you realistic problems.

In addition to the learning objectives listed above, this activity will help you effectively work in a team and share ideas with your friends.

Activity 1:

WHY SHOULD WE WORK ON EXISTING DESIGNS?

Improving existing designs is as important as coming up with new ones. It helps you take advantage of the vast knowledge resources that already exists. The idea of using existing designs for your needs is typically called adapting designs.
WHY SHOULD WE BRAINSTORM?

Whether you build a design or modify an existing one, brainstorming is an integral part of the process. Now think, what do you like about brainstorming with your friends? What do you dislike about it?

HOW TO USE SCAMPER?

When you brainstorm, it is always useful to be systematic by having a checklist of things you want to discuss – this will help you from going off-topic. SCAMPER is exactly that! It is a checklist of issues to consider when modifying an existing design. Using SCAMPER you will have a checklist that will be a guideline to help you think about a design problem.

WHAT DOES SCAMPER STAND FOR?

Substitute one thing for another

Combine with other materials/devices/functions

Adapt: Can you change the design for another use?

Minimize/magnify/modify

Put to other uses

Eliminate/elaborate: Remove or refine a part

Reverse/rearrange: Move things around, work backwards from the desired solution
EXAMPLE SCAMPER ACTIVITY

Next, let’s walk through how SCAMPER can be applied to modify the design of a water bottle to suit a school student. The ideas given below are merely guidelines. What other ideas do you have? For every idea that you come up with, evaluate its advantages and disadvantages as we have below.

Example SCAMPER activity – Use the SCAMPER tool to modify the design of a water bottle to best suit a school student

Most common existing design: Plastic water bottles

SUBSTITUE

Idea: Use a different material for the water bottle’s body – steel or clay.

Advantages: Steel bottles can be used for extended periods & won’t start smelling bad. Clay bottles will keep the water cool during the summer.

Disadvantages: Steel and clay bottles will be heavier than plastic bottles. And clay bottles can crack and leak water.
**COMBINE**

**Idea:** To have two compartments, one for water and one for milk or juice (combines the functions of 2 bottles)

**Advantages:** You can have two different drinks from the same bottle

**Disadvantages:** The individual compartments will be small if you don’t want the size of the bottle to increase by much.

---

**ADAPT**

**Idea:** Have a second opening near the bottom from which you can squirt out water to water the plants or play with friends

**Advantages:** You don’t have to make holes in the water bottle for the above purposes

**Disadvantages:** If you don’t remember to shut the second opening, water may leak everywhere.
**Idea:** Fill with sand and grow plants  
**Advantage:** Sustainable way to reuse old bottles  
**Disadvantage:** There is not enough room for all plants to grow well, and hard to mix the soil.

---

**MAGNIFY/MINIMIZE/MODIFY**

**Idea 1 (Magnify):** Make a bigger water bottle so you can carry more water  
**Advantage 1:** You will have water throughout the day  
**Disadvantage 1:** Bigger bottles are heavier to carry

**Idea 2 (Minimize):** Make a small water bottle that can fit in your school bag or pocket  
**Advantage 2:** You can carry it around everywhere  
**Disadvantage 2:** Your water will finish quickly

**Idea 3 (Modify):** Fit the bottle with a strap so you can tie it around your waist, upper arm or to some part of your cycle  
**Advantage 3:** You can carry around a slightly bigger bottle everywhere  
**Disadvantage 3:** Hard to move your body freely

---

**PUT TO OTHER USES**
**ELABORATE/ELIMINATE**

**Idea 1 (Elaborate):** Make the bottle's base bigger

**Advantage 1:** Bottle with less water or empty bottle won’t tip over in the wind due to its lower center of gravity

**Disadvantage 1:** May be harder to carry around or fit in the school bag

**Idea 2 (Eliminate):** Get rid of the bottle's neck so that the bottle looks like a tall glass with a lid & the mouth is wide

**Advantage 2:** More volume

**Disadvantage 2:** Possibility of spilling water while drinking.

---

**REARRANGE/REVERSE**

**Idea:** If the bottle has a straw or spout at its mouth, it can be moved to the bottom

**Advantage:** Easier to pour water if the spout is at the bottom. You can drink water lying down and keeping the bottle upright.

**Disadvantage:** Spout/straw has a possibility of getting worn out sooner.
You should have gotten a fairly good idea about how to use SCAMPER tool. **Now, it’s your turn to use it!**

---

### LET US DESIGN USING SCAMPER!!

Given below is a list of design problems – you can choose **ONE** and apply SCAMPER to make design modifications. If you want to work on your own design problem, try to think of designs or processes surrounding sustainability.

- **a)** A blackboard duster
- **b)** A backpack for one of the following clients:
  - School student
  - School teacher
  - Farmer going to work in the field
  - Your mother going to buy groceries
  - Your mother going to buy groceries with your one-year old brother or sister
  - Someone who works in a quarry
  - Jeep or lorry driver
- **c)** Serving midday meals or mid-morning milk at school (process innovation)

**Note:** One of the choices above (midday meal scheme) involves using SCAMPER on a process instead of a physical design. Are there any other processes in your village – ration shops, water supply from a nearby well, river or vendor,

---

Use the brainstorming sheet given below to help you get started!
BRAINSTORMING SHEET

1. Activity leader:

2. Name one device or process that you think is well designed. List 3 things that you like about it.

3. Name one device or process that you think is poorly designed. Why (list the 3 main problems with it)?

4. Problem you are choosing to work on (circle your choice):
   - Blackboard duster
   - Backpack (write down the client)
   - Midday meals or mid-morning milk
   - Other (please describe)

5. We chose to work on this problem because.....
6. The 3 main advantages of the existing design or process are.....

7. The 3 main problems with the existing design or process are.....

Use the ‘Design Analysis Sheet’ in the next page to guide you as you use SCAMPER. You can use the below table for reference.

<table>
<thead>
<tr>
<th>SCAMPER</th>
<th>Questions to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitute</td>
<td>What can be used instead? What materials can be used instead? What can be done instead?</td>
</tr>
<tr>
<td>Combine</td>
<td>How can you combine purposes? How can you combine processes/steps?</td>
</tr>
<tr>
<td>Adapt</td>
<td>What other device performs a function similar to this</td>
</tr>
<tr>
<td>Process</td>
<td>Question</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Modify</td>
<td>What can be changed?</td>
</tr>
<tr>
<td>Magnify</td>
<td>How can you make a part of the object or the object itself bigger or stronger? How can you scale the process up?</td>
</tr>
<tr>
<td>Minimize</td>
<td>How can you make a part of the object or the object itself smaller? How can you scale the process down?</td>
</tr>
<tr>
<td>Put to other uses</td>
<td>Who else can use this object? What else can this object be used for (without modifying it)? What else can this process be used for?</td>
</tr>
<tr>
<td>Eliminate</td>
<td>What parts of the object can be eliminated? What steps of the process can be eliminated?</td>
</tr>
<tr>
<td>Elaborate</td>
<td>What parts of the object can be developed more? What steps of the process can be</td>
</tr>
<tr>
<td>Rearrange</td>
<td>Can you move parts of the object around? Can you rearrange the steps of the process?</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Reverse</td>
<td>What can be placed/done in the opposite direction? Ask yourself what changes would make this object or process worse. So, what changes should you NOT implement?</td>
</tr>
</tbody>
</table>

At the end of the activity, please fill out the Self-Reflection Sheet so that you can see if you enjoyed working in a team.
DESIGN ANALYSIS SHEET

1. Activity leader:

2. Design problem you are working on:

3. Use the SCAMPER tool to improve the design!
   - Substitute
     Idea:
     Advantages:
     Disadvantages:
   - Combine
     Idea:
     Advantages:
     Disadvantages:
   - Adapt
Idea:

Advantages:

Disadvantages:

• Magnify/minimize/modify

Idea:

Advantages:

Disadvantages:

• Put to other uses

Idea:

Advantages:

Disadvantages:

• Eliminate/elaborate

Idea:

Advantages:
Disadvantages:

- Rearrange/reverse Idea:

Advantages:

Disadvantages:

4. Of the changes you have suggested above, select those changes that go best together (circle them above) and combine them so that you have the best final product.

5. Draw your final product (if it’s a process, you can draw a block diagram or a picture).

6. Our final design is better than the original product or process because.....
7. The original product or process is better than our final design because....

8. Overall, circle the better option:
   - Our final design
   - The original product or process

9. Finally, rate your design on the following statements from 1 to 5, with 1 being that the statement is true and 5 being that the statement is false.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials used to make the product are non-toxic, biodegradable or/and recyclable</td>
<td></td>
</tr>
<tr>
<td>The process of making the product will use minimal natural resources (like grid electricity from coal, water, trees etc.)</td>
<td></td>
</tr>
<tr>
<td>Materials used to make the product are locally available</td>
<td></td>
</tr>
<tr>
<td>Someone in the village can make or source the product you designed on a commercial scale and hence make a living</td>
<td></td>
</tr>
<tr>
<td>The process you designed uses minimal natural resources (like grid electricity, water, trees etc.)</td>
<td></td>
</tr>
<tr>
<td>The process you designed uses minimal human labor</td>
<td></td>
</tr>
<tr>
<td>The process you designed creates jobs for people</td>
<td></td>
</tr>
</tbody>
</table>
SELF-REFLECTION SHEET

1. Name –
2. My biggest contribution to the team was.....

3. I could have been more helpful if......

4. My team members worked well together because....

5. My team faced the following challenges:

6. I tried to overcome these challenges by....

7. If I had to rate my contributions to the team, I would give myself a ........ out of 10.

8. If I had to rate my team members, I would give:

<table>
<thead>
<tr>
<th>Name of team member</th>
<th>Score out of 10</th>
<th>Reason</th>
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CAN YOU BUILD A RUBE GOLDBERG MACHINE?!

Time needed: 2 days (2 sessions)

LEARNING OBJECTIVES

- To get practice building and debugging a device that performs a specific task.
- To understand the importance of creativity in the design process.

WHY?

The Rube Goldberg machine is a fun way for students to work on the design and construction of a device that performs a specific task. This activity will expose you to the engineering design process, of which creativity forms an integral part.

ACTIVITY 1:

Engineering design plays a very important role in our lives. How many of the things that you use on a daily basis have been designed by engineers? Engineers try to find practical solutions to problems or improve existing designs.

The following is a framework for the engineering design process, which will guide you while you work on your Rube Goldberg machines.
What is a Rube Goldberg machine?

It is a fun machine that accomplishes a simple task in a complex way. It is made of common household items like buckets, marbles, strings, wheels, sticks etc. These machines became popular because of a cartoonist called Rube Goldberg, who made comics mocking industrialization.

Why should we work with Rube Goldberg machines?

1. They’re fun!
2. It helps you think about how to use different household items creatively
3. It will help you indirectly understand physics concepts such as motion, friction, energy transfer and momentum.
4. At the end of the activity, you will have a low-cost machine that performs a simple task for you!
You can watch some videos of Rube Goldberg machines that others have built.

1. To pour water in a glass:
   [http://www.youtube.com/watch?v=Y4kyTZgp1HE](http://www.youtube.com/watch?v=Y4kyTZgp1HE)

2. To staple a piece of paper:
   [http://www.youtube.com/watch?v=rX7yCnbp9bQ](http://www.youtube.com/watch?v=rX7yCnbp9bQ)

3. To light up a sparkler using a candle flame:
   [http://www.youtube.com/watch?v=eSyCDyNf5K4](http://www.youtube.com/watch?v=eSyCDyNf5K4)

A typical Rube Goldberg machine will consist of simple machines (levers, pulleys, screws, wedges, inclined planes & wheels and axles), constructed using some or all of the following parts:

1. Marbles
2. Books
3. Straws
4. Cups
5. Pipes or chart paper tubes
6. Stones
7. Funnels
8. Toy cars
9. Rubber bands
10. Magnets
11. Sticks
12. Water
13. Sand
14. Swings
15. Rubber bands
16. Batteries
17. Wires
18. Light bulbs
The most common simple machines used in a Rube Goldberg machine are inclined planes, pulleys and levers.

A Rube Goldberg machine works through a series of steps or “energy transfers”, as you can see from the videos.

You can use the Brainstorming Sheet to plan out your design.

**BRAINSTORMING SHEET**

**DESIGN GUIDELINES:**

- The Rube Goldberg machine is normally designed such that it is started by a single action such as dropping a marble down a ramp, cutting a string or removing a barrier
- No additional human action is required once the machine starts
- The machine should have at least 3 distinct steps or energy transfers
1. Activity leader:

2. The task that you would like your Rube Goldberg machine to perform:

Hint: If you have trouble identifying a task, you can pick one from the following list:

- Turn on a light bulb by completing a circuit
- Put out a candle flame
- Pop a balloon
- Staple two sheets of paper together
- Fill a cup with water
- Ring a bell
- Empty a cup of water
- Fill a bowl with food for cows
- Shut a door

3. Chart out your design visually.
   - Draw a block diagram with the first step (your action to start the machine) and the last step (the final task you want to accomplish).
• Next, work on one intermediate step at a time. Be as creative as possible.
• Make a rough list of the materials you will need for each step.

You can now begin to work on your design!

Remember that you might have to change some of the steps in your design because they may not work or because of the shortage of materials. Keep track of these changes in your journals!
SELF-REFLECTION SHEET

1. Name –

2. My biggest contribution to the team was.....

3. I could have been more helpful if......

4. My team members worked well together because....

5. My team faced the following challenges:

6. I tried to overcome these challenges by....

7. If I had to rate my contributions to the team, I would give myself a .......... out of 10.

8. If I had to rate my team members, I would give:

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LOCAL LIVELIHOODS

Time needed: 1 day (1 session)

LEARNING OBJECTIVES

• To identify the difficulties faced by people of a particular profession & brainstorm possible solutions

• To understand the concept of a process innovation

WHY SHOULD WE UNDERSTAND LOCAL LIVELIHOOD?

We can equip people of our village with skills to come up with various kinds of innovations. Some of them may involve building a new device, while others may involve coming up with process innovations. This activity will help you think about solutions to problems faced by people working in a particular profession, many of which will involve process innovations. This activity will also help increase your empathy towards the community.
ACTIVITY 1:

HOW DO we innovate for our village?

You should try to work on projects that will benefit your community. One of the best places to start thinking about possible innovations is by exploring the needs of a particular livelihood. You have already identified some needs of people working in these livelihoods using the Needs’ Assessment Toolkit.

Now, you can begin to work on the next stage by brainstorming solutions to these needs.

The solutions can be:

- New devices that can be built, which could better the lives of people working in that profession (Eg. you could propose building a coconut plucking machine, which could make the lives of coconut tree climbers better)
- Process innovations – For example, you can work out the model for having a local vendor of seeds in every village.

In this activity, you will apply the SCAMPER tool on the livelihood option that you studied using the Needs’ Assessment Toolkit.

You can use the following table for reference and the Brainstorming Sheet to help you brainstorm ideas for your innovation.
<table>
<thead>
<tr>
<th>SCAMPER</th>
<th>Questions to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitute</td>
<td>What can be used instead? What materials can be used instead? What can be done instead?</td>
</tr>
<tr>
<td>Combine</td>
<td>How can you combine purposes? How can you combine processes/steps?</td>
</tr>
<tr>
<td>Adapt</td>
<td>What other device performs a function similar to this device? How can you modify this device to perform that purpose? What other process is similar to this process? How can you modify the steps of this process to suit those needs?</td>
</tr>
<tr>
<td>Modify</td>
<td>What can be changed?</td>
</tr>
<tr>
<td>Magnify</td>
<td>How can you make a part of the object or the object itself bigger or stronger? How can you scale the process up?</td>
</tr>
<tr>
<td>Minimize</td>
<td>How can you make a part of the object or the object itself smaller? How can you scale the process down?</td>
</tr>
<tr>
<td>Put to other uses</td>
<td>Who else can use this object? What else can this object be used for (without modifying it)? What else can this process be used for?</td>
</tr>
<tr>
<td>Eliminate</td>
<td>What parts of the object can be eliminated? What steps of the process can be eliminated?</td>
</tr>
<tr>
<td>Elaborate</td>
<td>What parts of the object can be developed more? What steps of the process can be developed more?</td>
</tr>
<tr>
<td>Rearrange</td>
<td>Can you move parts of the object around? Can you rearrange the steps of the process?</td>
</tr>
</tbody>
</table>
**BRAINSTORMING SHEET**

1. Activity leader:

2. Livelihood you are working on:

3. Draw a block diagram of the steps involved in a day, week or year of someone in this profession.

**Reverse** | What can be placed/done in the opposite direction? Ask yourself what changes would make this object or process worse. So, what changes should you NOT implement?
---|---

4. Top three problems faced by people working in this profession (from your assessment of the needs of this livelihood)

Now, use the SCAMPER tool to come up with possible solutions to the problems faced by people in this livelihood.

Note: You should consider problems related to:

- Convenience (for both the workers and “customers”)
- The environment
- Economics

When you think about advantages & disadvantages, you should do so in the context of these 3 categories.

1. Substitute

Pointers:

- Can you substitute a step in the block diagram with something else?
- Can you suggest an alternative (for instance, can vendors selling only coconuts substitute the product with some other vegetable?)?

Idea:
Advantages:

Disadvantages:

2. **Combine**
   Pointers:
   - Can you combine 2 or more livelihood options?
   - Can you combine 2 or more steps in your block diagram?

Idea:

Advantages:

Disadvantages:

3. **Adapt**
   Pointers:
   - Can you adapt practices from other professions to this one?
   - Can you adapt (or take advantage of) other skills or devices to this profession?
• Can the byproducts of this profession be adapted for some other use?

Idea:

Advantages:

Disadvantages

4. Magnify/Minimize/Modify
   Pointers:
   • Any ideas for carrying out the activities of the livelihood on a bigger or smaller scale?
   • Any ideas for modifying a step in the block diagram – do you think something should be done differently?

Idea:

Advantages:

Disadvantages:
5. **Put to other uses**

Pointers:

- Do you think outcomes of this profession can be used for something else?
- Do you think the byproducts can be used for something else?

Idea:

Advantages:

Disadvantages:

6. **Elaborate/eliminate**

Pointers:

- Can you get rid of a step in your block diagram?
- Does a step in the block diagram need to be refined?

Idea:
Advantages:

Disadvantages:

7. **Rearrange/reverse**

Pointers:
- Do the steps in the block diagram need to be rearranged?

Idea:

Advantages:

Disadvantages:

8. Of the changes you suggested using SCAMPER, what are the top 3 ones that you would incorporate?
9. Do the changes you suggested address:
   a) Environmental sustainability? How?

   b) Economic sustainability? How?

   c) Social sustainability? How?
LOCALLY AVAILABLE MATERIALS

Time needed: 4 days (4 sessions)

LEARNING OBJECTIVES

1. To work on real, hands-on design projects from beginning to end
2. To think about environmental sustainability by using locally available materials in their designs
3. To think about economic sustainability by evaluating the pros and cons of commercializing your designs within the community.

WHY SHOULD WE DESIGN WITH LOCALLY AVAILABLE MATERIALS?

From the perspective of the rural ecosystem, it is important to equip yourself not only with design skills, but also practical knowledge about sustainability. Designing with locally available materials will help you use the resources that are readily available in your communities.

WHY THINK ABOUT ENVIRONMENT AND ECONOMIC SUSTAINABILITY?

Thinking about environmental sustainability will help you evaluate the environmental impact of these materials & the design process. Thinking about economic sustainability will help you identify opportunities and explore if they can be translated into alternative livelihoods.
Activity 1:

Do you remember the ‘Locally Available Materials’ module from the last phase, when you explored the following properties?

1. Waterproofing ability
2. Thermal insulation
3. Tensile strength
4. Heat content (of different kinds of firewood)

In this activity you will get to work on a design project, in which the challenge is to use locally available materials wherever possible. Remember that locally available materials can be naturally occurring materials like wood, stone, grass, soil etc. or common waste products in the community like cloth, paper, plastic etc.

There are two main ways to approach such a design problem:

1. Identify a need and explore how and whether locally available materials can be used to build the solution
2. Think about how the different properties of locally available materials can be exploited and retrospectively fit in your designs as solutions for needs.

In the 1st phase, you roughly followed the 2nd approach. However, in this activity, you will largely be following the 1st approach.
EXAMPLE – MAKING A PAPER CUP CHAIR

Let’s now think about an example design project using a common waste material in cities – paper cups.

OPPORTUNITY

People who live in cities or travel by train are uses and throw a lot of paper cups. Can these cups be reused for something useful?

GOAL OF THIS EXAMPLE

- To demonstrate how waste products can be reused
- To give you a slightly more global perspective on the idea of using locally available materials, since paper cups are probably not used in the village
- To introduce you to the iterative process involved in designing. The iterative process is shown below:
IDEAS

a. Reuse them for drinking – Can these pose hygiene problems?
b. Grow plants in them – Are the cups too small for that?
c. They kind of look like columns. Test them for their compressive strength & perhaps use them to make a stool or chair?

MATERIALS YOU MIGHT NEED TO TEST THE CUPS FOR THEIR COMpressive STRENGTH

1. Several cups
2. Sand or salt
3. A weighing scale
4. Marbles or pebbles
5. A wide wooden slab (wide enough to be a comfortable seat)
Other factors to consider for a holistic design!

1. Environmental sustainability:

   Good – We are reusing paper cups. The insides of paper cups are lined with waterproof material, which makes them non-recyclable.

   Bad – Ideally, we would want people to STOP using paper cups!

2. Economic sustainability:

   Materials needed for making the chair:

   1. Disposed paper cups – Rs. 200
   2. Wooden slab for seat,
   3. Tape or rope for reinforcement – Rs. 100
   4. Sand

   Estimate materials cost for one chair = Rs. 300

   Other resources:

   1. Human labor for collecting disposed paper cups, testing and building the final design;
   2. Marketing/advertising the new product;

   Estimate resource cost for one chair = Rs. 200

   Total cost: Rs. 500
Good – Presumably cheap chairs with reused materials. So people may be willing to buy them if we decide to commercialize the design.

Bad – What if people stop using paper cups because of increased awareness? We would then face a shortage of “raw materials” for our design! But presumably, this won’t happen for a long time...

HOW WOULD YOU DESIGN THE TEST?

You would first have to test the compressive strength of one cup. This can be done by placing the cup on the weighing scale (face up or face down?) and then holding onto a support like a chair, you stand on the cup with one foot, slowly transferring more of your body weight to the cup. You can measure the reading of the scale when the cup collapses. This will give you an idea of the compressive strength of the cup. Okay, so now you know the compressive strength of one cup!

NOW, LET’S THINK ABOUT THE CHAIR YOU WANT TO DESIGN...

What are the features your chair should have (these are the “specifications”)? (You can also draw your idea)
1. Should be able to support your weight
2. Should be comfortable
3. Should be easy to carry around

Note: The last two points are things you can possibly add to the design at a later stage. But the most important part is to figure out if the chair will support your weight.
DESIGNING A CHAIR THAT CAN SUPPORT YOUR WEIGHT

Things to consider:

- Number of cups (will more cups lead to more strength?)
- Arrangement of cups (should you arrange the cups in rows, in a circular pattern or some other shape?)

Are columns in buildings filled with something? Yes, concrete.

- Weight of the cups – can you fill the cups with sand or marbles?
- Type of filling – will cups filled with smaller particles (Eg. sand) be stronger than cups filled with larger particles (Eg. marbles or pebbles)?

THE DESIGN PROCESS – ITERATIVE!

Test the weight that a particular design (Eg. cups arranged in rows and filled with nothing) can support → Try to improve the design (Eg. cups arranged in rows but now filled with sand) → Test → Repeat process of refinement

Note: Detailed pointers are given merely as a guideline to walk you through the thought process. You should try to come up with your own ideas during the example. The idea of the example is not to design a chair, but to expose you to the process of designing a chair.
**ACTIVITY 2:**

In this activity, you will get a choice of 2 semi-independent design problems, for which you will have to use locally available materials. You only have to do **ONE** of the two.

Choices:

1. Design a water purification system to get rid of bacterial contamination
2. Design a refrigerator that doesn’t use electricity

Note: If you want to work on a different design problem, feel free to do so after checking with your facilitator.

Tick your choice and proceed.

**Design your own water purification system to remove microbial contamination!**

**BACKGROUND**

Microbial contamination in water, especially drinking water can cause many diseases such as cholera, E-coli etc. There are several ways to get rid of microbial contamination in water. The WHO (World Health Organization) standard is to boil water for around 3 minutes at ~ 85 °C – or to heat it until it reaches a rolling boil. Remember that boiling water doesn’t remove chemical toxins like agricultural run-offs, but we are not worried about them in this activity. **Here, you will explore the best water purification system that can remove microbial contamination because there is a firewood shortage in your village and you don’t want to boil water.**

**Note:** Please don’t drink the water purified by your system since chemical toxins might still be present!
We will give you a few options for materials to use:

1. Drumstick kernels
   More information: 
   [http://miracletrees.org/moringa_water_purification.html](http://miracletrees.org/moringa_water_purification.html)

2. Coconut husk
   More information: 
   [http://thisbigcity.net/could-coconuts-purify-urban-water-supplies/](http://thisbigcity.net/could-coconuts-purify-urban-water-supplies/)

3. Any 2 traditional methods used in the village or 2 other locally available materials

You will have to compare the microbial contamination level with the contamination level after boiling water and identify the best method for purification, given a firewood shortage.

**WHAT SHOULD YOU DO?**

You should read the given references and figure out how to use drumstick kernels and coconut husk to purify water. Then, talking to community members or doing some research, identify two more purifying methods that use locally available materials.

Design your 4 different water purification systems:

- One with drumstick kernels
- One with coconut husk
- One each with each of the locally available materials that you identified.

Compare the microbial contamination in the water purified in these 4 different ways with the microbial contamination in the water after boiling.
After this, you should design the water purification system using the best purifying agent. For this part, you will have to think about factors like aesthetics, convenience of use etc.

Now, you can brainstorm ideas with your team members using the Brainstorming Sheet.
**BRAINSTORMING SHEET**

**Design problem:** Design a water purification system that will remove microbial contamination, with naturally available materials (and without boiling)

Activity leader:

1. **Opportunity**

2. **Ideas**
   1. Drumstick kernels
   2. Coconut husk
   3. ......................
   4. ......................

3. **Materials you might need for the design**

4. **Other factors to consider for a holistic design**
a. **Environmental sustainability**
   
   **Good:**
   
   **Bad:**

b. **Economic sustainability**

   **Materials needed:**

   **Approximate materials cost:**

   **Other resources needed:**

   **Approximate cost for other resources:**

   **Good:**

   **Bad:**

5. **How would you design the test to identify the best purifying agent?**

   Remember, you will have to COMPARE different purifying agents in order to identify the best one.
6. **Now, think about the purification system you want to design**
   The main features (specifications) that your system must have (add more to the list if you wish) are:
   1. Water can’t leak out of the system
   2. The system is no bigger than 1 m x 1 m x 1 m
   3. The system can purify around 1-3 liters at a given time

7. **Things to consider while identifying the best purifying agent**
   Some ideas:
   - Is it easily available?
   - Is it cheap?
   - Will a combination of 2 or more of the options work better?

**Note:** You should bring the necessary materials or arrange to get them through the facilitator for the next session. Remember you should try to use locally available materials for all the parts of your system.

**Good luck!**
DESIGN A REFRIGERATOR THAT DOESN'T USE ELECTRICITY!

BACKGROUND

How many of you have refrigerators at home? Now, how many of you have wanted to drink some cold water or lemon juice in the summer? Or, have you heard your mothers complain about not being able to keep vegetables and milk fresh for long periods of time? What if you could build your own refrigerator that doesn’t use electricity!!!

Here, you will explore how to design your own refrigerator by using locally available materials.

One of the most common scientific ideas used in natural refrigerators is that of EVAPORATIVE COOLING and this is the concept that you will use for your design too.

EVAPORATIVE COOLING:

This is cooling through evaporation. We all experience it when we sweat. We actually feel cool when the sweat evaporates from our skin. This is because water needs heat to change into its vapor state & when the sweat from our skin evaporates, the water absorbs some of our body heat, hence making us feel cooler.

Also, it is an experimental fact that a fixed amount of heat needs to be supplied to a liquid to vaporize it & this value is different for different liquids. At normal room temperature, the heat of vaporization for water is HUGE – 580 calories per gram!
Given below are a few references that will help you come up with the best design.

**References:**

1. The “Terracooler”:
   - Video:  
     [https://www.youtube.com/watch?feature=player_embedded&v=zWcaRoBOHtk](https://www.youtube.com/watch?feature=player_embedded&v=zWcaRoBOHtk)  
     Picture of the design:

   ![Figure 1: Sketch of the Terracooler design](http://terracooler.org)

2. Zeer pot fridge (pot-in-pot fridge):
   - Link: [http://practicalaction.org/zeer-pot-fridge](http://practicalaction.org/zeer-pot-fridge)
Video:
https://www.youtube.com/watch?feature=player_embedded&v=ZNKifjHqScc

WHAT SHOULD YOU DO?

After going through the references given above you should try to come up with a refrigerator design for your house or the school kitchen. You can adapt the ideas in the references or introduce some modifications.

Here are some quick facts about the rate of evaporation of water that can help you while designing:

The rate of evaporation of water increases if:

1. You increase the surface area of the water
2. You decrease the air pressure
3. You can increase the rate of evaporation if there is a breeze

Also note that the rate of evaporation will decrease if the climate is humid.

Now, you can brainstorm ideas with your team members with the Brainstorming Sheet.
BRAINSTORMING SHEET

Design problem: Design a refrigerator that doesn’t use electricity, using locally available materials

Activity leader:

1. Opportunity

2. Ideas
   Some things to consider:
   - Are there other ways in which the mud in the Zeer pot fridge can stay cooler? Is the ground under a tree cooler? So, can you grow plants in that mud?

   The modification that you want to introduce in your design

3. Materials you might need for the design
   Note: To test if your fridge actually has a cooling effect, it might be helpful to monitor the temperature of the food items your place in it.
4. **Other factors to consider to create a holistic design**
   - **Environmental sustainability**
     
     Good:
     
     Bad:
     
   - **Economic sustainability**
     
     Materials needed:
     
     Estimate materials cost:
     
     Other resources needed:
     
     Estimate cost of other resources:
     
     Good:
     
     Bad:

5. **Now, think about your refrigerator design:**
   
   Some features (specifications) it should have are:
1. It shouldn’t be bigger than 1mx1mx1m
2. It should be able to keep milk or spinach fresh for at least one day

**Note:** You should bring the necessary materials or arrange to get them through the facilitator for the next session. Remember you should try to use locally available materials for all the parts of your system.

**Good luck!**
ACTIVITY 3:

You will work on the design of your solution in the next 2 days. You can use the Design Analysis Sheet to help guide your thoughts during the design process. Please ensure that you have the necessary materials required for the design projects.

GOAL OF THE DESIGN ACTIVITY

Remember that the goal of this activity is for you to get accustomed to the design process, rather than to produce a groundbreaking design (which would be an unfair expectation in 2 days!). So, while you work on their design, you are encouraged to:

- Keep thinking of ways to modify or improve their design
- Think of the sustainability aspects – environmental, economic and social
- Social sustainability is a vague concept & is difficult to understand even for an adult– but in some cases, it is quite obvious. For example, suppose the women in a village have to walk several kilometers every day to get safe drinking water. If you design an environmentally and economically sustainable water purifier, the women don’t have to put in that extra effort to get drinking water. This design then, is sensitive to the needs and convenience of an important section of society. This could lead to better social relations – for instance, women can spend more time with their families, women can spend more time on recreational activities etc. This is an example of social sustainability.

Think of whether your design is socially sustainable.

- When talking about economic sustainability, think about existing products that perform the same purpose (Eg. electricity-run fridges). How are their designs better than these existing products? This would determine the salability of your designs.
At the end of the session, please fill out the Self-Reflection sheet to see if you enjoyed working in a group!

DESIGN ANALYSIS SHEET

Design problem:

Activity leader:

Phase 1 – Testing:

1. Draw a neatly labeled picture of your test setup.
   (For the water purification system design, your test setup consists of the different purifying agents you are testing. For the refrigerator design, your test setup consists of the basic design of your cooler.)

2. If you are taking measurements or observing something during the test process, record these in a tabular format.
3. Conclusion – Have you finalized your basic design? If so, draw your basic design below.
(For the water purification system design, you should have identified the best purifying agent.
For the refrigerator design, you should have finalized the basic design of your cooling system.)

4. Briefly describe how your design works (you can use a block diagram).
Phase 2 – Refinements to include other factors

1. What will you add to your design to make it look appealing (think about what kind of water purifier or refrigerator you would be willing to pay for)?

2. Are these additions:
   a) Environmentally sustainable?

   b) Economically sustainable?

3. Draw a picture of your final design.
4. Final list of materials you need for the design.

5. How did you construct your design? (Use a block diagram)

6. How much time did it take to construct the design?

7. How much did the materials cost?
8. Do you think your design is value for money?

9. Who are the potential customers for your design?

10. Are all the materials you used locally available?

11. Can excess materials be disposed of easily?
SELF-REFLECTION SHEET

1. Name –
2. My biggest contribution to the team was…..

3. I could have been more helpful if…..

4. My team members worked well together because….

5. My team faced the following challenges:

6. I tried to overcome these challenges by….

7. If I had to rate my contributions to the team, I would give myself a .......... out of 10.

8. If I had to rate my team members, I would give:

<table>
<thead>
<tr>
<th>Name of team member</th>
<th>Score out of 10</th>
<th>Reason</th>
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SUSTAINABILITY IN PRACTICE

Time needed: 4 days (4 sessions)

LEARNING OBJECTIVES

1. To explore sustainable practices and their connection to science and technology
2. To carry out an independent study of sustainable practices and evaluate their local applicability

WHY?

In this module, you will independently study a sustainable practice and evaluate its local applicability, based on your understanding of the needs, opportunities and constraints in the village. Each team will then present its findings to the rest of the class.

In addition to achieving the learning objectives, this module aims to give you a global perspective of sustainable practices and hone your presentation skills – both of which are important tools from the point of view of an inventor or innovator.
ACTIVITY 1:

BEHOLDING THE IDEA OF SUSTAINABILITY

The whole program has been building up to the 3\textsuperscript{rd} phase, in which you can work on finding a solution to a problem in the village. For this, you have been equipped with \textbf{critical thinking skills} in the 1\textsuperscript{st} phase and \textbf{design skills} in the 2\textsuperscript{nd} phase. The idea of sustainability should be the common thread through all your projects – that solutions should have minimum environmental impact, while being economically and socially beneficial.

This activity brings sustainability to the forefront – helping you realize that many problems you face in the village can have sustainable solutions, and that these problems and solutions are to a large extent, universal.

HOW TO PROCEED WITH THE ACTIVITY

You will be given a list of sustainable practices, from which you will choose \textbf{one to do background research on}. You will then evaluate the adaptability of this practice in your village by discussing with your team members and other community members. If you wish, you can build a small working model to demonstrate the idea to community members. You will then present your findings to the rest of the class.

The problems that you will get in this section are very diverse and require a varied set of skills. Some problems might require you to build things, while others might require you to talk to community members and yet others may require you to do a lot of background research. Some guidelines will be given to help you, but this activity is a largely independent one.
NATURAL VENTILATION

WHAT?
It is the process of increasing air-flow in an indoor space without using mechanical systems. This is possible by exploiting temperature and pressure differences between indoor and outdoor spaces.
WHY?
It gets very hot during the summers and we spend a lot of money cooling buildings using fans and in cities, air conditioners. This is a huge energy cost that can be reduced using natural ventilation.

KEY POINTS TO REMEMBER
- One of the main ways to cool is using wind. Faster moving air cools things faster because it carries the heat away faster and helps evaporate sweat. This is idea behind fans.
- The concept of natural ventilation uses many ideas you learnt in the Air Pressure and Heat modules like Bernoulli's principle, pressure differences and convection.

Here are some references that will give you a better idea about natural ventilation:

a) Wind ventilation: The practice of using local air pressure differences to induce air flow --
http://sustainabilityworkshop.autodesk.com/buildings/wind-ventilation

b) Stack ventilation & Bernoulli’s principle: The practice of using pressure difference due to height to induce air flow –
c) Night purge ventilation: The practice of using cool air at night to ventilate a place –

http://sustainabilityworkshop.autodesk.com/buildings/night-purge-ventilation

**WHAT SHOULD YOU DO?**

The approach you take for this activity is left to you, but here is a rough guideline:

1) Explore traditional architectural designs that increase natural ventilation in the village

2) Evaluate the differences between the traditional designs and the ideas in the references

3) Explore how much energy is consumed on cooling (fans, ACs etc) – can you use the Energy Needs Assessment module?

4) Explore if there is a need for introducing sustainable architectural practices that increase natural ventilation in the village by talking to community members

5) What do you think is the one design you will pitch to the community?

6) Brainstorm how you will pitch your idea to the community

7) Make a presentation explaining your findings and approach

No other guidelines such as the Brainstorming Sheet or Design Analysis Sheet will be given. But it is encouraged that your team
effectively documents its work, like you have been throughout the toolkit. Always remember to consider how this idea will contribute to the 3 aspects of sustainability: environmental, economic and social.

Good luck!
IRRIGATION USING CAPILLARY ACTION

WHAT?

The principle of capillary action can be used to design a low-cost and passive irrigation system that provides a constant source of moisture to plants.

WHY?

These kinds of irrigation systems can be designed for small areas like kitchen gardens. It can also be used on small-scale farms. They are also low-cost and don’t use too much power.

Recall the experiment on capillary action that you did in the Fluids module. Discuss with your team members what you recall from that activity.

How do you think capillary action can be used to design an irrigation system?

Here are a few references that will give you more ideas:

WHAT SHOULD YOU DO?

The approach you take for this activity is left to you, but here is a rough guideline:

1) Understand how capillary action can be taken advantage of when designing an irrigation system. Try to come up with your own ideas, instead of relying too much on the given references.

Some things to consider are:

a) What soil type is this suitable to?

b) What kind of plants will grow best if the soil is constantly moist?

c) What are its advantages?

d) What are its disadvantages?

e) What is the rough size of the farm that you can irrigate using this method?

f) What are the power requirements – do you need to use a pump?

2) What are the irrigation methods used in the village?

3) Do a comparison of these methods and a system using the principle of capillary action.

4) Will this method be suitable for a section of the community?

5) If there isn’t an existing opportunity for using capillary irrigation systems, can you create an opportunity? For instance, could a cluster of houses have a community kitchen garden that you can irrigate using this system?

6) How will you pitch your idea to the community?

7) Make a presentation explaining your findings and approach.

No other guidelines such as the Brainstorming Sheet or Design Analysis Sheet will be given. But it is encouraged that your team effectively documents its work, like you have been throughout the toolkit. Always remember to consider how this idea will contribute to the 3 aspects of sustainability: environmental, economic and social.

Good luck!
BUILDING A SOLAR COOKER

WHAT?
Solar cookers are devices used to cook food by focusing the sun’s heat on a region.

WHY?
Solar cookers are a simple way to reduce the consumption of other types of cooking fuel like firewood, kerosene or LPG.

KEY POINTS TO REMEMBER ABOUT CONCENTRATING SUN’S HEAT

• You can use a reflecting surface to reflect the sun’s heat that falls on it into the solar cooker – this is normally done using mirrors or aluminum foil
• Black surface are better at absorbing heat than light-colored surfaces. So, normally the insides of solar cookers are lined with black-colored paper or painted black to increase heat absorption
• Convection is a method of heat transfer, as you learnt in the Heat module. You can prevent convective losses of heat from the cooker by making it air tight
• Finally, you learnt about how insulators don’t let heat flow through them easily in the Heat module. To prevent conductive heat losses, you can line the cooker with a cheaply available insulating material such as newspaper.
MATERIALS NEEDED

• Cardboard box
• Pencil, ruler, scissors
• Aluminum foil
• Clear tape
• Black paper (preferably construction paper) or paint
• Large & transparent plastic bag or plastic wrap
• Newspaper
• Dish in which you can cook Maggi

INSTRUCTIONS

1. Draw a square around 1 inch from the edges of the top of the box
2. Cut three of the four sides of this square so that the top of the box forms a flap. This will be the lid of your solar cooker.
3. Find a way to ensure that the flap stands up
4. Cover the inside of the flap completely with aluminum foil
5. What does the foil do?
6. Line the inside of the box’s base with the black paper or cover it with black paint
7. What does the black surface do?
8. Cut the plastic bag or wrap into small pieces and tape them along the insides of the base. What is the purpose of the plastic bag?
9. Roll the newspaper into tubes and again, tape them along the sides of the base. What does the newspaper do?
10. Now, you can stark cooking in your solar cooker (it is best to cook using it between 11 and 2 am)!
WHAT SHOULD YOU DO?

The approach you take for this activity is left to you, but here is a rough guideline:

1) Explore the cooking practices in the village. Have you already done this using the Needs Assessment Toolkit? What are the main sources of cooking fuel? How much money do people spend on cooking?

2) Make an assessment of the time that people are willing to spend on cooking. And at what time of the day do people normally cook?

3) Talk to community members about the concept of a solar cooker. You can try building one on your own to make your discussions more effective.

4) Explore ways in which solar cookers can be introduced into the community. Think of the following:

   a) Will it be a good idea for each person to build his/her own cooker?
   b) Will it be a good idea for someone in the village to take building solar cookers as a livelihood option?
   c) What are the main problems that people might face cooking with solar cookers as opposed to firewood, kerosene or LPG?
   d) What are the key ways in which the quality of life will improve if people switch to using solar cookers?

5) Make a presentation of your findings and approach
No other guidelines such as the Brainstorming Sheet or Design Analysis Sheet will be given. But it is encouraged that your team effectively documents its work, like you have been throughout the toolkit. Always remember to consider how this idea will contribute to the 3 aspects of sustainability: environmental, economic and social.

**Good luck!**

**ADDRESSING NUTRIENT DEFICIENCIES IN THE VILLAGE**

**WHAT?**

You already know from the nutrition module that it is important to have a well-balanced diet. When we don’t have enough of a certain nutrient, we suffer from a nutrient deficiency.

**WHY?**

Being healthy becomes vital to do our daily activities. The health of the individual depends a lot on their diet. Hence it is important that people in the village have good health and they are able to contribute to the village to their best.
Are there any nutrient deficiencies in the village that you know of? What are they?

You can find more information about nutrient deficiencies in this reference:


**WHAT SHOULD YOU DO?**

1. Talk to different community members to identify the main deficiencies in the village. You can survey either children, old people or middle-aged people.
2. Try to understand the steps taken by villagers to address this deficiency. Is there any locally available food that is rich in these nutrients?
3. Compare the knowledge with the information given in the reference.
4. Can you think of a way to address this deficiency? Think of the following:
   a) How will you go about creating awareness about the deficiency and the ways to address it?
   b) Are your proposed solutions easily implementable?
   c) Is there any overlap between your proposed solution & traditional practices?
   d) How can you avoid such deficiencies in the future?
5. Make a presentation of your findings and approach
No other guidelines such as the Brainstorming Sheet or Design Analysis Sheet will be given. But it is encouraged that your team effectively documents its work, like you have been throughout the toolkit. Always remember to consider how this idea will contribute to the 3 aspects of sustainability: environmental, economic and social.

**Good luck!**
For more details contact

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education@selcofoundation.org

'Illustrations by Sushmitha V, Design by Anantha Murthy'.