CASE STUDIES

Survival in the Desert Sun: Cool Food Storage

Priti Parikh and Andrew Lamb

PHOTO: Using a Zeer pot to keep fruit and vegetables cool in Sudan. Practical Action.

GDEE GLOBAL DIMENSION IN ENGINEERING EDUCATION

CASE STUDIES **Survival in the Desert Sun: Cool Food Storage**

EDITED BY
Global Dimension in Engineering Education

COORDINATED BY
Agustí Pérez-Foguet, Enric Velo, Pol Arranz, Ricard Giné and **Boris Lazzarini** (*Universitat Politècnica de Catalunya)*
Manuel Sierra *(Universidad Politécnica de Madrid)*
Alejandra Boni and **Jordi Peris** *(Universitat Politècnica de València)*
Guido Zolezzi and **Gabriella Trombino** *(Università degli Studi di Trento)*
Rhoda Trimingham *(Loughborough University)*
Valentín Villarroel *(ONGAWA)*
Neil Nobles and Meadhbh Bolger *(Practical Action)*
Francesco Mongera *(Training Center for International Cooperation)*
Katie Cresswell-Maynard *(Engineering Without Border UK)*

DL B 10735-2015
ISBN 978-84-606-7546-4

Citation: Parikh, P. and Lamb, A. (2015) 'Survival in the Desert Sun: Cool Food Storage', in *Case studies for developing globally responsible engineers*, GDEE (eds.), Global Dimension in Engineering Education, Barcelona. Available from: http://gdee.eu/index.php/resources.html

SURVIVAL IN THE DESERT SUN: COOL FOOD STORAGE

Dr. Priti Parikh, University College London.
Andrew Lamb, Engineers Without Borders UK.

INDEX

1. INTRODUCTION ... 3

1.1. DISCIPLINES COVERED ... 3

1.2. LEARNING OUTCOMES ... 3

1.3. ACTIVITIES ... 4

2. DESCRIPTION OF THE CONTEXT ... 4

2.1. LIVING IN NORTH DARFUR ... 4

2.2. EVAPORATIVE COOLING ... 6

2.3. ZEER POT CLAY REFRIGERATOR ... 6

2.4. OTHER DESIGNS OF EVAPORATIVE COOLERS ... 8

2.5. PRACTICAL ACTION SUDAN ... 9

3. CLASS ACTIVITY ... 10

3.1. ACTIVITY ... 10

3.2. SOLUTION AND EVALUATION CRITERIA ... 13

4. HOMEWORK ACTIVITY ... 16

4.1. TASK ... 16

4.2. PREPARATION ... 17

4.3. EVALUATION CRITERIA ... 17

4.4. USING WIKIS IN EDUCATION - RESOURCES ... 19

BIBLIOGRAPHY ... 20

1. INTRODUCTION

The Global Dimension in Engineering Education (GDEE) is a European Union funded initiative involving the collaboration of development NGOs and universities, with an aim to integrate sustainable human development as a regular part of all technical university courses. Part of the initiative is the development of a set of case studies based on real field experiences of development projects. The case studies cover a broad range of topics directly related those studied in engineering, science and other technology, environment or development-related courses.

This case study looks at a technology that people who live in the heat and dust of North Darfur use to preserve their food. It is a clay and sand pot called a Zeer Pot. When placed in the sunshine, it uses the phenomena of evaporative cooling to cool the vegetables stored inside it. This is of vital importance to people for their own food supplies and for affordably preserving food for market. The case study is based on work by Practical Action Sudan (Practical Action Nepal, 2014).

The case study allows students at any level to: understand factors influencing the performance of evaporative cooling pots; learn about another use of solar energy (other than photovoltaics and water heating etc) in enabling sustainable human development; realise the extreme vulnerability to disaster of many millions of people and how good engineering can help reduce their vulnerability; appreciate the beginner’s confusion over technology choice; experience the challenges of communicating the design of even a simple technology.

Images for this case study can be found in the associated PowerPoint presentation.

1.1. DISCIPLINES COVERED

Thermodynamics; Materials Science; Sustainability; Economics; Appropriate Technology. Other aspects include: Development; Entrepreneurship; Social Sciences.

1.2. LEARNING OUTCOMES

1. The positive impact of even a ‘basic technology’ (uses basic principles) on people’s lives.
2. An understanding of the engineer’s role in technology choice.
3. The challenge and importance of effectively communicating know-how about technology ensure that the technology is used properly.

1.3. Activities

Class Activity: Individual work, and calculations about the performance of refrigeration pots for a variety of storage conditions.

Homework Activity: Individual work, and a web activity – writing an online guide for making a cooling device.

2. Description of the context

The following sections outline the situation in the North Darfur region of Sudan, evaporative cooling, the Zeer Pot and a number of other evaporative cooler designs. The case study is therefore, in itself, a demonstration of the issue of technology choice; there are many ways to cool vegetables without needing power, but which one should be used? Hopefully, the case study will offer some surprising and inspiring ideas to students: that the sun can be used to cool; that there are so many ways to cool food without power; that communicating how to make even a simple pot can be very hard; the vulnerability of people over food; etc.

The case study could be extended to include: practical activities where groups of students make, use and analyse Zeer Pots themselves; issues of climate change; the role of engineers in communicating and sharing technology; the ironies in the history of technology – such as that we live in a world that uses electrical cooling thanks to the advancement of technology in rich, cold countries but that we now need to re-discover evaporative cooling from poor, hot countries to help reduce climate change (caused by rich country technologies). The final activity will also allow for the exploration of issues surrounding wikis.

2.1. Living in North Darfur

Sudan is Africa's third largest country and the third largest Arab country (Wikipedia, 2014). About 85% of poor people in Sudan depend on agriculture or animal husbandry or both. Recurrent drought and flash floods can cause food insecurity for farmers, pastoralists and their families. Limited natural resources also contribute to conflict at local level.

Sudan's Darfur region in the west is made up of five states. North Darfur is the largest of these with an area roughly equivalent to the total area of United Kingdom and Ireland together. The northern part of the state is desert, and the west and the south are dominated by the Marrah mountains. The eastern part of the state has low sandy hills and plains, and it is here that the state's 1,500,000 people is concentrated (Wikipedia, 2014). 80% of North Darfur's population lives in rural areas practicing agriculture and animal rearing.

North Darfur is geographically remote from the rest of the country; El Fasher, the capital of North Darfur is more than 1,000 km from Sudan's capital, Khartoum. This remoteness – combined with the insecurity and marginalisation – contributes to poor services delivery, lack of markets access and the slow pace of humanitarian aid. The disruptive effects of the Darfur conflict are most felt in the areas of agriculture, food security, livestock, education, health, and personal security. Ongoing asset stripping, restriction of movement, rape and harassment, further impinge on these sectors. Each renewed conflict means a break in the food aid pipeline, and increased prices of essential supplies (including fuel). This situation has meant collapse of traditional and supplementary livelihoods and general food insecurity. Vulnerability has increased, especially of women and children.
On the southern edge of the Sahara desert and lying within Africa's arid zone, North Darfur State offers extremely difficult conditions for growing food, raising livestock and living. Declining rainfall over recent years has led to low production of crops, which makes households vulnerable to food crises. When there is a good production season, farmers often need technical know-how on food processing and storage to help overcome supply problems in poor growing years.

The staple crop is millet, planted on large areas of sandy goz soil as well as on smaller areas of alluvial soils. Households grow part of their annual consumption requirements. Watermelon is the main intercrop, which provides useful cash income. Livestock have traditionally been part of the North Darfur rural production system, with camels, sheep, cattle and goats all owned in small numbers by farming households. Other livelihoods that supplement agriculture and livestock rearing are labour migration, trade and collection of firewood and fodder.

Few families have alternative livelihood skills to rely on during bad harvests. Traditional coping mechanisms such as reducing the number of meals eaten in a day, over-grazing and over-cultivation can be harmful to the families and to the environment.

In hot climates such as that in North Darfur, food doesn't stay fresh for long. Tomatoes go off in just two days. After four days carrots and okra are rotten. With no means of preserving their crops, poverty stricken families battle hunger and even famine.

Much of the post-harvest loss of fruits and vegetables in developing countries like Sudan is due to the lack of proper storage facilities. While refrigerated cool stores are the best method of preserving fruits and vegetables, they are expensive to buy and run. Consequently in developing countries there is interest in low-cost alternatives, many of which depend on evaporative cooling which is simple and does not require a power supply.

According to a 2014 report, it is estimated that about 25% of food waste in developing countries could be eliminated with better refrigeration equipment and that up to 50% of fruit and vegetables are lost in sub-Saharan Africa (IMechE, 2014).

2.2. Evaporative Cooling

The basic principle relies on cooling by evaporation, which is a process of heat exchange. When water evaporates, its relatively high specific heat capacity draws energy from its surroundings and produces a considerable cooling effect. Evaporative cooling occurs when air (that is not too humid) passes over a wet surface; the faster the rate of evaporation the greater the cooling. Evaporative coolers need to be replenished with water for cooling to continue.
The efficiency of an evaporative cooler depends on the humidity of the surrounding air. Very dry air can absorb a lot of moisture so greater cooling occurs. In the extreme case of air that is totally saturated with water, no evaporation can take place and no cooling occurs.

Side Note on Biomimicry:
Human bodies sweat in hot temperatures to allow for evaporative cooling from the skin. In dry heat sweating can be very effective (indeed, evaporation can happen so quickly that you may not even notice that you are sweating). In humid weather sweating is far less effective. Staying hydrated whilst sweating is essential to allow the process of evaporative cooling to continue. The use of evaporative cooling to cool food is therefore an example of 'biomimicry' where the design of a technology is inspired and informed by natural biological solutions.

2.3. Zeer Pot clay refrigerator

A Nigerian teacher called Mohammed Bah Abba first developed the Zeer pot in the 1990s. It consists of a small-scale storage 'pot-in-pot' system that uses two pots of slightly different size made of local materials. The smaller pot (which can be glazed) is placed inside the larger pot and the gap between the two pots is filled with sand, which is kept moist with water. As the sun shines on the outer pot, water evaporates from the sand through the porous ceramic and the food in the smaller pot inside is cooled. Up to 12kg of fruit and vegetables can be stored. Mohammed won the Rolex 200 Award for Enterprise for his design. Zeer is the Arabic name for the pots used.

In Sudan, Practical Action and the Women's Association for Earthenware Manufacturing have conducted experiments on the effectiveness of the Zeer Pot storage design of Mohammed Bah Abba. The results are shown in the following table:

Produce	Shelf-life without using the Zeer	Shelf-life using the Zeer
Tomatoes	2 days	20 days
Guavas	2 days	20 days
Rocket	1 day	5 days
Okra	4 days	17 days
Carrots	4 days	20 days

As a result of the tests, the Woman's Association for Earthenware Manufacturing started to produce and market the pots specifically for food preservation.

Case study on Hawa Abbas:

In the hot weather of North Darfur, Hawa Abbas used to lose half of her tomato, okra and carrot crop. Her world changed when she began working with Practical Action. As she herself says, "*After many years of struggle, Practical Action came and showed us how to make pottery refrigerators. They are made in two different sized pots. The smaller is put inside the bigger one and in between we put sand and wet it with water and cover it. They keep our vegetables fresh for 3-4 weeks, depending on the type of crop. They are very good in a hot climate such as ours where fruit and vegetables get spoiled in one day. Since I learned how to make zeer pots our life has been so much better.*"

Making and using a Zeer Pot Refrigerator:

- First, bowl-shaped moulds are created from mud and water – and left to dry in the sun. Clay is then pressed onto the moulds to form the desired size of pot. Clay rims and bases are added and the moulds are removed. The pots are left to dry in the sun.

- Once the pots have been fired in a pit of sticks, the zeer pot is ready to assemble. A smaller pot is placed inside a larger one, and the space in between filled with sand.

- The whole structure is then placed on a large iron stand. This allows the air to flow underneath and aid the cooling process.

- Twice a day, water is added to the sand between the pots so that it remains moist. The entire assembly is left in a dry, ventilated place.

- Fruit, vegetables and sorghum – a type of cereal prone to fungal infestation if not preserved – are then placed in the smaller pot, which is covered with a damp cloth or lid.

2.4. Other designs of Evaporative coolers

- Janata Cooler: One adaptation on the basic double pot design is the Janata cooler. A storage pot is placed in an earthenware bowl containing water. The pot is then covered with a damp cloth that is dipped into the reservoir of water. Water drawn up the cloth evaporates keeping the storage pot cool. The bowl is also placed on wet sand, to isolate the pot from the hot ground.

- Bamboo cooler: The base of the cooler is made from a large diameter tray that contains water. Bricks are placed within this tray and an open weave cylinder of bamboo or similar material is placed on top of the bricks. Hessian cloth is wrapped around the bamboo frame, ensuring that the cloth is dipping into the water to allow water to be drawn up the cylinder's wall. Food is kept in the cylinder with a lid placed on the top.

- Almirah Cooler: the Almirah is a more sophisticated cooler that has a wooden frame covered in cloth. There is a water tray at the base and on top of the frame into which the cloth dips, thus keeping it wet. A hinged door and internal shelves allow easy access to the stored produce.

- Charcoal cooler: The charcoal cooler is made from an open timber frame of approximately 50mm x 25mm in section. The door is made by simply hinging one side of the frame. The wooden frame is covered in mesh, inside and out, leaving a 25mm cavity which is filled with pieces of charcoal. The charcoal is sprayed with water, and when wet provides evaporative cooling. The framework is mounted outside the house on a pole with a metal cone to deter rats and a good coating of grease to prevent ants getting to the food. The top is usually solid and thatched, with an overhang to deter flying insects. All cooling chambers should be placed in a shady position, and exposure to the wind will help the cooling effect. Airflows can be artificially created through the use of a chimney. For example using a mini electric fan or an oil lamp to create airflows through the chimney – the resulting draft draws cooler air into the cabinet below the chimney.

- Bhartya cool cabinet: Uses the chimney effect to cool produce. Wire mesh shelves and holes in the bottom of the raised cabinet ensure the free movement of air passing over the stored food.

- Static cooling chambers: The basic structure of the cooling chamber can be built from bricks and river sand, with a cover made from cane or other plant material and sacks or cloth. There must also be a nearby source of water. Construction is fairly simple. First the floor is built from a single layer of bricks, then a cavity wall is constructed of brick around the outer edge of the floor with a gap of about 75mm between the inner wall and outer wall. This cavity is then filled with sand. About 400 bricks are needed to build a chamber of the size shown in Figure 3 which has a capacity of about 100kg. A covering for the chamber is made with canes covered in sacking all mounted in a bamboo frame. The whole structure should be protected from the sun by making a roof to provide shade. After construction the walls, floor, sand in the cavity and cover are thoroughly saturated with water. Once the chamber is completely wet, a twice-daily sprinkling of water is enough to maintain the moisture and temperature of the chamber. A simple automated drip watering system can also be added.

- Naya cellar storage: A brick-lined chamber dug into the ground, with an outer and inner wall where the cavity is filled with sand. It is covered by a thatched roof.

2.5. Practical Action Sudan

Practical Action Sudan (Practical Action Sudan, 2014) is the local office of the international development charity Practical Action (Practical Action, 2014), which is headquartered in the UK. It was founded by the economist E. F. Schumacher who is known for writing ‘Small Is Beautiful’ and who coined the term ‘Intermediate Technologies’ (Schumacher, 1973), which became known as ‘Appropriate Technologies’.

Practical Action Sudan is currently operating in three geographical areas, in Kassala State, North Darfur State and Blue Nile State. Practical Action Sudan’s work is structured under three organisational themes: energy; food security, livelihoods and disaster risk reduction; and urban sanitation. Particular attention is paid to disadvantaged sections of the community such as poor families, households headed by women, the disabled or other marginalised groups. Practical Action Sudan works closely with beneficiary communities and applies a participatory methodology in assessing peoples' needs, monitoring progress and impact and developing and transferring technologies. The work aims to reduce people's vulnerability to disasters, mainly war and drought, and build their resilience to cope with disasters.

Activities implemented in North Darfur have focused on community capacity building and improved technological responses to poverty and displacement. Interventions start with organising communities in organisations, building community managed assets such as tools and seeds stores and community based extension services, then facilitating access to water spreading techniques (dams & terraces), animal restocking and food processing and preservation skills.

3. Class Activity

3.1. Activity

The briefing to students is as follows (reproduced in *'Activity 1 handout for students'*):

The success of the pot is highly dependent on the extent of evaporative cooling which in turn is dependent on how the pots are stored and exposure to fresh air. Research was conducted with market sellers in Sudan to assess difference in performance for various scenarios of storage. In this activity let us assess the difference in performance for the following scenarios and discuss the results:

1. Estimate and discuss the difference in performance between a clay refrigerator kept in confined space (3 sides and above) with one that is unconfined although not exposed to the sun. This test compared two pots at the same time thereby fixing the variables of temperature, humidity, time of watering and amount of water as shown in the table below:

Date	Watering Time (1st) and No of liters	Watering Time (2nd) and No of liters	Time and Temp Outside in shade	Relatively Humidity	Time and Temp inside Refrigerator A	Time and Temp inside Refrigerator B
16/6/09	8.35 - 1.5 l	18:45 - 1 l	12:15 - 45.5º	12	12:30 - 36º	12:30 - 35º
17/6/09	9:30 - 1.5 l	5:30 - 1 l	13:00 - 45.5º	11	13:15 - 36º	13:15 - 35º
18/6/09	9:15 - 1 l		12:30 - 39º	27	12:50 - 33 º	12:45 - 32.5 º
19/6/09	12:30 - 1 l	4:05 - 1/2 l	12:10 - 39.5º	27	12:25 - 36 º	12:25 - 34º
21/6/09	9:30 - 1 l		12:00 - 44 º	21	12:15 - 38 º	12:15 - 35º

Factor ii	Confined refrigerator on the roof; covered from 3 sides and above		Refrigerator B
Factor iii	Unconfined refrigerator on the roof in the shade		Refrigerator A

2. Estimate and discuss the difference in performance between an unconfined pot refrigerator exposed to sunlight for the whole day versus a refrigerator pot unconfined in the shade. Since it was not possible to conduct testing for the two pots on the same day readings were taken on days with a temperature difference of less than 2.5° and humidity difference of less than 3%. The table below provides data for two groups, in the first group there are four readings (or days) and for the second group only one set of reading (days) which fits this criteria:

Date	Watering Time (1st) and No of liters	Watering Time (2nd) and No of liters	Time and Temp Outside in shade	Relatively Humidity	Time and Temp inside Refrigerator
Group 1 (2 readings x 2 readings)					
Cross reference 1					
11/6/09	9:30 – 1.5 l	19:00 – 1 l	12:15 - 45.5°	13	12:00 - 38.5°
16/6/09	8:35 - 1.5 l	18:45 - 1 l	12:15 - 45.5	12	12:30 - 36°
Cross reference 2					
12/6/09	10:30 – 1.5 l	17:00 – 1 l	12:15 - 45°	11	12:00 - 40.5°
17/6/09	9:30 - 1.5 l	5:30 - 1 l	13:00 - 45.5°	11	13:15 - 36°
Cross reference 3					
11/6/09	9:30 – 1.5 l	19:00 – 1 l	12:15 - 45.5°	13	12:00 - 38.5°
17/6/09	9:30 - 1.5 l	5:30 - 1 l	13:00 - 45.5°	11	13:15 - 36°
Cross reference 4					
12/6/09	10:30 – 1.5 l	17:00 – 1 l	12:15 - 45°	11	12:00 - 40.5°
16/6/09	8:35 - 1.5 l	18:45 - 1 l	12:15 - 45.5	12	12:30 - 36°
Group 2 (1 reading x 1 reading)					
Cross reference 1					
24/6/09	10:20 - 1 l	5:30 - 1 l	13:05 - 46.5°	29	13:20 - 41°
28/6/09	9:00 - 1.5 l	18:25 - 1/2 l	13:15 - 44°	26	13:15 - 38.5°

Factor i	Unconfined refrigerator on the roof not in the shade	
Factor iii	Unconfined refrigerator on the roof in the shade	

3. Estimate and discuss the difference in performance between an unconfined pot on the roof in shade and an unconfined pot raised 30cm from the roof floor. Both pots are in the shade. Since it was not possible to conduct testing for the two pots on the same day readings were taken on days with a temperature difference of less than 2.5° and humidity difference of less than 3%. The table below provides data for two groups, in the first group there are four readings (or days) and for the second group two set of readings:

Date	Watering Time (1st) and No of liters	Watering Time (2nd) and No of liters	Time and Temp Outside in shade	Relatively Humidity	Time and Temp inside Refrigerator
Group 1 (2 readings x 2 readings)					
Cross reference 1					
19/6/09	12:30 - 1 l	4:05 - 1/2 l	12:10 - 39.5 °	27	12:25 - 36 °
29/6/09	9:35 - 1 l	17:10 - 1 l	12:45 - 38.5°	29	13:00 - 33.5°
Cross reference 2					
18/6/09	9:15 - 1 l		12:30 - 39°	27	12:50 - 33 °
30/6/09	9:30 - 1 l	18:15 - 1 l	13:00 - 39°	30	13:15 - 33.5°
Cross reference 3					
19/6/09	12:30 - 1 l	4:05 - 1/2 l	12:10 - 39.5 °	27	12:25 - 36 °
30/6/09	9:30 - 1 l	18:15 - 1 l	13:00 - 39°	30	13:15 - 33.5°
Cross reference 4					
18/6/09	9:15 - 1 l		12:30 - 39°	27	12:50 - 33 °
29/6/09	9:35 - 1 l	17:10 - 1 l	12:45 - 38.5°	29	13:00 - 33.5°
Group 2 (2 readings x 1 reading)					
Cross reference 1					
28/6/09	9:00 - 1.5 l	18:25 - 1/2 l	13:15 - 44°	26	13:15 - 38.5°
1/7/09	9:15 - 1 l	17:15 - 1 l	13:45 - 43°	26	13:30 - 35.5°
Cross reference 2					
25/6/09	9:15 - 1 l	18:00 - 1 l	13:00 - 42°	26	13:00 - 35°
1/7/09	9:15 - 1 l	17:15 - 1 l	13:45 - 43°	26	13:30 - 35.5°

Factor iii	Unconfined refrigerator on the roof in the shade	
Factor iv	Refrigerator (on the roof) on a stand raised approx 30 cm from the ground (in the shade)	

3.2. Solution and Evaluation Criteria

1. Since the pots were compared at the same time we can directly compare and tabulate the temperature differences between the two pots – see last column:

Date	Watering Time (1st) and No of liters	Watering Time (2nd) and No of liters	Time and Temp Outside in shade	Relatively Humidity	Time and Temp inside Refrigerator A	Time and Temp inside Refrigerator B	Temp Difference (A from B)
16/6/09	8.35 - 1.5 l	18:45 - 1 l	12:15 - 45.5°	12	12:30 - 36°	12:30 - 35°	1
17/6/09	9:30 - 1.5 l	5:30 - 1 l	13:00 - 45.5°	11	13:15 - 36°	13:15 - 35°	1
18/6/09	9:15 - 1 l		12:30 - 39°	27	12:50 - 33 °	12:45 - 32.5 °	0.5
19/6/09	12:30 - 1 l	4:05 - 1/2 l	12:10 - 39.5°	27	12:25 - 36 °	12:25 - 34°	2
21/6/09	9:30 - 1 l		12:00 - 44 °	21	12:15 - 38 °	12:15 - 35°	3

Therefore, the average temperature difference between the two pots is:
= (Total of temp differences between the two pots) / No. of days of testing
= (1+1+0.5+2+3) / 5
= 1.5°
This means that the refrigerator in confined space is cooler by 1.5°

The evaporative process generally requires fresh air and hence this result is slightly surprising as intuitively one would think that a non-confined pot would be more efficient and note lower temperatures inside the pot. An explanation for this could be that the one side of pot was explored for refrigerator B which facilitated the cooling. Another explanation could be related to the fact that both pots were still stored in the shade on the roof.

2. It is worth noting humidity as an important factor influencing the performance of the pots. Big temperature differences usually occur on days with low levels of relative humidity as can be seen from the temperature readings for Group 2. Ideally temperatures need to be measured on the same day for the two points to discount variations in humidity and daily temperatures. The readings in the table below were collated to minimise differences in day temperatures and humidity so we can still estimate average temperature differences – see last column:

Date	Watering Time (1st) and No of liters	Watering Time (2nd) and No of liters	Time and Temp Outside in shade	Relatively Humidity	Time and Temp inside Refrigerator	Temp Difference
Group 1 (2 readings x 2 readings)						
Cross reference 1						
11/6/09	9:30 – 1.5 l	19:00 – 1 l	12:15 - 45.5°	13	12:00 - 38.5°	7°
16/6/09	8:35 - 1.5 l	18:45 - 1 l	12:15 - 45.5	12	12:30 - 36°	9.5°
Cross reference 2						
12/6/09	10:30 – 1.5 l	17:00 – 1 l	12:15 - 45°	11	12:00 - 40.5°	4.5°
17/6/09	9:30 - 1.5 l	5:30 - 1 l	13:00 - 45.5°	11	13:15 - 36°	9.5°
Cross reference 3						
11/6/09	9:30 – 1.5 l	19:00 – 1 l	12:15 - 45.5°	13	12:00 - 38.5°	7°
17/6/09	9:30 - 1.5 l	5:30 - 1 l	13:00 - 45.5°	11	13:15 - 36°	9.5°
Cross reference 4						
12/6/09	10:30 – 1.5 l	17:00 – 1 l	12:15 - 45°	11	12:00 - 40.5°	4.5°
16/6/09	8:35 - 1.5 l	18:45 - 1 l	12:15 - 45.5	12	12:30 - 36°	9.5°
Group 2 (1 reading x 1 reading)						
Cross reference 1						
24/6/09	10:20 - 1 l	5:30 - 1 l	13:05 - 46.5°	29	13:20 - 41°	5.5°
28/6/09	9:00 - 1.5 l	18:25 - 1/2 l	13:15 - 44°	26	13:15 - 38.5°	5.5°

Therefore, the average temperature difference between the two pots is:

= (Total of temp differences between the two pots) / No. of cross reference checks

= (2.5+5+2.5+5+0)/5

= 3°

This means that keeping the refrigerator in shade decreases the temperature by 3° inside the refrigerator pot. This finding is intuitive as exposure to direct sunlight would reduce the refrigerator performance and hence the siting of the pot is important. The warmer the climate the greater would be impact on refrigeration performance. It would be good to test the above for two pots on the same day to discount the possible influence of humidity and day time temperature differences.

3. Ideally temperatures need to be measured on the same day for the two points to discount variations in humidity and daily temperatures. The readings in the table below were collated to minimise differences in day temperatures and humidity so we can still estimate average temperature differences – see last column:

Date	Watering Time (1st) and No of liters	Watering Time (2nd) and No of liters	Time and Temp Outside in shade	Relatively Humidity	Time and Temp inside Refrigerator	Temp Difference
Group 1 (2 readings x 2 readings)						
Cross reference 1						
19/6/09	12:30 - 1 l	4:05 - 1/2 l	12:10 - 39.5 °	27	12:25 - 36 °	3.5
29/6/09	9:35 - 1 l	17:10 - 1 l	12:45 - 38.5°	29	13:00 - 33.5°	5
Cross reference 2						
18/6/09	9:15 - 1 l		12:30 - 39°	27	12:50 - 33 °	6
30/6/09	9:30 - 1 l	18:15 - 1 l	13:00 - 39°	30	13:15 - 33.5°	6.5
Cross reference 3						
19/6/09	12:30 - 1 l	4:05 - 1/2 l	12:10 - 39.5 °	27	12:25 - 36 °	3.5
30/6/09	9:30 - 1 l	18:15 - 1 l	13:00 - 39°	30	13:15 - 33.5°	6.5
Cross reference 4						
18/6/09	9:15 - 1 l		12:30 - 39°	27	12:50 - 33 °	6
29/6/09	9:35 - 1 l	17:10 - 1 l	12:45 - 38.5°	29	13:00 - 33.5°	5
Group 2 (2 readings x 1 reading)						
Cross reference 1						
28/6/09	9:00 - 1.5 l	18:25 - 1/2 l	13:15 - 44°	26	13:15 - 38.5°	5.5
1/7/09	9:15 - 1 l	17:15 - 1 l	13:45 - 43°	26	13:30 - 35.5°	7.5
Cross reference 2						
25/6/09	9:15 - 1 l	18:00 - 1 l	13:00 - 42°	26	13:00 - 35°	7
1/7/09	9:15 - 1 l	17:15 - 1 l	13:45 - 43°	26	13:30 - 35.5°	7.5

Therefore, the average temperature difference between the two pots is:

= (Total of temp differences between the two pots) / No. of cross reference checks

= (1.5+0.5+3-1+2+0.5)/6

= 1.1°

This means that keeping the refrigerator in an elevated position decreases the temperature by an average of 1.1° inside the refrigerator. The results suggest that the pot should be kept elevated to facilitate air circulation and cooling of the pots.

4. Homework activity

4.1. Task

This is a web-based exercise that draws upon both the student's understanding of evaporative cooling technologies and their communication skills.

The briefing to students is as follows (reproduced in 'Activity 2 handout for students'):

"*It is often difficult to communicate the knowledge and principles behind a technology, even if we can assume a good level of literacy amongst the audience. But it is even more difficult to communicate the know-how of how to build, use and maintain a technology. Access to engineering know-how is a significant barrier to development for many people in places like North Darfur. As access to communications media such as the Internet increases around the world, the problem becomes one of how we deliver know-how effectively.*

Many solutions to this problem are emerging. They aim to help people to help themselves, rather than being dependent on outside engineers or international aid assistance. They aim to support the sustainability of a technology too – helping people to understand and maintain the technology in the longer term. Many of these solutions depend on the ability and commitment of engineers to share their know-how freely and effectively.

In this exercise, you will write an article on the Appropedia wiki (www.appropedia.org) about an evaporative cooler of your choice. You will be assessed equally on what you write and on how well you write it; because the ultimate challenge is to ensure that your reader will be able to read your article and understand how to make the device. To do this effectively, you will need to develop your own understanding of how to use the wiki platform, the best practices used in the platform (see below) as well as a gain a solid understanding of the evaporative cooler itself. For the sake of the exercise, imagine that your reader is a subsistence farmer in a developing country who is fluent in English and who has completed school with a basic understanding of science.

The whole exercise should take you no more than twelve hours. Suggested steps are:

1. *Review the list of evaporative coolers on Appropedia at www.appropedia.org/Evaporative_Cooling_(original) and search the internet for any other designs. Select a particular evaporative cooler for your article. [1 hour].*
2. *Conduct personal research to learn about the evaporative cooler and how to make it. This might include literature review online (including videos) and at your university libraries. Select sources with care, using your judgement as an engineer. [2 hours].*
3. *Familiarise yourself with Appropedia and its styles and conventions by exploring www.appropedia.org and create your own (private) user account [1/2 hour].*

4. *Use the details provided by your lecturer to start a new page on Appropedia for your article on your evaporative cooler in the appropriate place. Practice using Appropedia by referring to this guide www.appropedia.org/Help:Editing. [1/2 hour].*
5. *For some inspiration on style and structure, review this page on the Zeer Pot www.appropedia.org/Zeer_pot_refrigeration_(design) written by a student engineer from Canada (as part of research into the performance of the Zeer Pot). Review the article with a critical eye on style and structure to inform the style you use. [1/2 hour].*
6. *Write your article about your chosen evaporative cooler in Appropedia [6 hours].*
7. *Once completed, submit the article to your lecturer by sending them a link to your page and by telling them your username [1/2 hour].*

4.2. Preparation

Information about Appropedia can be found here: www.appropedia.org/Appropedia:About

Information on setting up the wiki for use with your students can be found here: www.appropedia.org/Appropedia:Service_learning/Guide which also contains some suggested briefing notes for you to give your students. It is suggested that you follow these instructions to create a category for your students to associate their article with. You can, if you wish, create a list of topics (types of evaporative coolers) for your students to choose from – but they can also refer to the list provided in the activity handout.

Do not hesitate to contact the Appropedia community (which includes teachers) for support.

Students submit work by emailing you their username and link to their article. You can review the history of their page to see which accounts have been editing its content.

4.3. Evaluation Criteria

The quality of students' work on this activity is assessed using two broad headings: 1) the know-how and level of detail communicated, and; 2) how well it is communicated. These are given equal weighting, because the effective communication of know-how depends as much on how well it is delivered as it does on the content itself. The suggested criteria are below.

A suggested grading is:

- A (80%+)
- B (70% - 79%)
- C (60% - 69%)
- D (50% - 59%)
- F (<50%).

Criteria	Weight	Marks	Maximum
Content: Experience as a reader • Can use the article to learn quickly and easily about the device, without prior knowledge • Allows you to make an informed decision about whether to choose this technology • An interesting read	3	Up to 5	15
Content: Level of detail • The device is explained accurately • Attention is paid to context • The advantages and disadvantages of the technology are mentioned	3	Up to 5	15
Content: Level of confidence • Questions raised in your mind about the device whilst reading are addressed • You feel you know how to make the device • Very few blanks that your imagination / assumptions / experience has to fill in	1	Up to 5	5
		Content sub-total:	**35**
Style: Well-written • The prose is clear and concise • It respects copyright laws • Spelling and grammar are correct • Clear and structures layout	3	Up to 5	15
Style: Broad in its coverage • Addresses the main aspects of the topic • Stays focused on the topic • Does not go into unnecessary detail	3	Up to 3	9
Style: Illustrated, if possible, by images • Images are tagged with their copyright status • Images are relevant to the topic • Images have suitable captions	2	Up to 3	6
Style: Verifiable with no original research • Contains a list of all references • Provides in-line citations from reliable sources • Contains no original research • Follows referencing style guide	1	Up to 3	3
Style: Neutral • Represents different viewpoints fairly	1	Up to 2	2
		Style sub-total:	**35**
		Grand total:	**70**

4.4. Using Wikis in Education - Resources

The following resources are aimed at academics who seek to use wikis in education. They are developed by JISC (www.jisc.ac.uk) which is a British organisation that supports university academics to make best use of information technology. The resources focus primarily on using Wikipedia in education, but can be generalised to apply to Appropedia and other wikis (such as www.wikihow.org and www.howtopedia.org etc).

- “Let’s get serious about Wikipedia”. A blog post outlining the uses of Wikipedia in higher education. www.jisc.ac.uk/blog/lets-get-serious-about-wikipedia-03-jul-2014
- “JISC Wikimedian Ambassador”. This is a blog run by JISC and the UK branch of the foundation that runs Wikipedia. http://wikiambassador.jiscinvolve.org/wp/
- “Crowdsourcing: the wiki way of working”. This is a general infokit that looks at using wikis for projects that support education and research. It includes introductions to the concepts behind wiki-based projects. www.jiscinfonet.ac.uk/infokits/crowdsourcing/
- “Wikipedia FAQs: Editing”. An overview of editing on the popular MediaWiki used by Wikipedia and Appropedia. https://en.wikipedia.org/wiki/Wikipedia:FAQ/Editing
- “Good articles in Wikipedia”. Explains how articles in Wikipedia are categorised as ‘good’ and (on a separate tab on the page) lists the criteria used to assess the quality of articles. https://en.wikipedia.org/wiki/Wikipedia:Good_articles

Bibliography

Benyus, J. M. (1992). *Biomimicry - Innovation Inspired by Nature.* New York: HarperCollins.

IMechE. (2014). *A tank of cold: Cleantech Leapfrog to a more Food Secure world.* London: Institution of Mechanical Engineers.

Practical Action. (2014, August). *Practical Action homepage*. Retrieved August 12, 2014, from Practical Action: www.practicalaction.org

Practical Action. (2014, August). *The Clay Refrigerator.* Retrieved August 12, 2014, from Practical Action: https://practicalaction.org/media/preview/10769

Practical Action. (2014, August). *Zeer pot fridge*. Retrieved August 12, 2014, from Practical Action Zeer Pot: https://practicalaction.org/zeer-pot-fridge

Practical Action Nepal. (2014, August). Retrieved August 2014, from Practical Action Nepal homepage: www.practicalaction.org/nepal

Practical Action Sudan. (2014, August). *Practical Action Sudan homepage*. Retrieved August 12, 2014, from Practical Action Sudan: www.practicalaction.org/sudan

Schumacher, E. F. (1973). *Small is Beautiful: A study of economics as if people mattered.* London: Blond & Briggs.

TBC. (1997, June). Cooling your cucumbers. (D. Dixon, Ed.) *Appropriate Technology, 24*(1), 27.

TBC. (2000, October-December). TBC. (D. Dixon, Ed.) *Appropriate Technology, 27*(4).

Wikipedia. (2014, August). *North Darfur page*. Retrieved August 12, 2014, from Wikipedia: https://en.wikipedia.org/wiki/North_Darfur

Wikipedia. (2014, August). *Sudan country page*. Retrieved August 12, 2014, from Wikipedia: https://en.wikipedia.org/wiki/Sudan

Further/suggested material

- Video: Zeer Pot Clay Fridge www.youtube.com/watch?v=ZNKifJHqScc
- Video: Zeer Pot hobbyist experiment www.youtube.com/watch?v=ZNLPeb3qIhc

GDEE

GLOBAL DIMENSION IN ENGINEERING EDUCATION

http://www.gdee.eu

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

UNIVERSITY OF TRENTO - Italy

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

POLITÉCNICA CAMPUS DE EXCELENCIA INTERNACIONAL

Loughborough University

ONGAWA INGENIERÍA PARA EL DESARROLLO HUMANO

Centro per la Formazione alla Solidarietà Internazionale
Training Centre for International Cooperation

PRACTICAL ACTION

engineers without borders uk

This project is funded by