From Waste to Paper - Logbook

An investigation into the suitability of crop residues as materials for paper

Sherie Pan
02/12/15

- Received SRP notification
- Random idea that could be used for SRP:
  - Friction of tyres/other things in relation to type of pattern/material

18/12/15

- Starting to brainstorm different ideas for SRP
- Created timetable:

<table>
<thead>
<tr>
<th>DECEMBER</th>
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<tbody>
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<thead>
<tr>
<th>JANUARY</th>
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<td>4</td>
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<tr>
<td>Research into topic</td>
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| 25                  | 26 | 27 | 28 | 28 | 30 | 31 |    |
|                     |    |    |    |    | Completed draft method and equipment list for SRP |    |    |
|                     |    |    |    |    | Collected all equipment that I can acquire by myself (not equipment that I may borrow from school) |    |    |

**FEBRUARY**

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<tbody>
<tr>
<td>Complete risk assessment and write up hypothesis</td>
<td>Start writing up summarised background research</td>
<td>Write up variables and continue writing background research</td>
<td>Write explanation of why method is valid</td>
<td>Work on proposal</td>
<td>Complete writing whole proposal</td>
<td>Edit and finalise proposal</td>
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<tbody>
<tr>
<td>Proposal due</td>
<td></td>
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<td>Ensure all equipment needed for trial has been collected</td>
<td>Conduct trial for experiment</td>
<td>Continue conducting trial</td>
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<tbody>
<tr>
<td>Begin writing up findings of trials if possible</td>
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<td>Conduct trial for 2nd time if necessary</td>
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<tr>
<td></td>
<td>Finish writing findings of trials</td>
<td></td>
<td>Log containing trials due</td>
<td></td>
<td>Conduct real experiment that will be recorded for SRP</td>
<td>Continue conducting experiment</td>
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| 29 | 30 |
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**MARCH**

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<td>Conduct real experiment for 2nd time if necessary</td>
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<td>Continue conducting experiment</td>
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<tr>
<td></td>
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<td>Begin to write up report (first half of report likely taken from proposal)</td>
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<tbody>
<tr>
<td>Begin writing discussion</td>
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<td>Review parts from proposal to see if anything needs to be changed</td>
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<tbody>
<tr>
<td>Edit and review report</td>
<td>Finish editing and formatting report</td>
<td>SRP final report &amp; log due</td>
</tr>
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</table>

**20/12/15**

- Used Google Science Fair Idea Springboard [www.googlesciencefair.com/springboard/en/](http://www.googlesciencefair.com/springboard/en/) to try to find ideas:
• Looked at following topics areas but didn’t find anything that interested me as an SRP topic:
  o Carbon dioxide scrubbing
  o Aerosols
  o Energy efficiency
  o Sustainable energy
  o Water quality
  o Recycling
  o Acid rain
  o Fossil fuels
  o Greenhouse gas
  o Ocean acidification
  o Adhesion
  o Viscoelasticity

21/12/15
• Continued searching for ideas on Google Springboard but found nothing

22/12/15
• Continued searching for ideas on Google Springboard
• Have mainly been looking at environmental and health-related topics
• Still haven’t found anything of interest

26/12/15
• Idea of doing something related to dust mite allergies came to mind as I recently found out I have a severe allergy to dust mites, but it doesn’t seem ideal to expose myself to more dust mites
• Came across the idea of doing something related to biofuels on www.sciencebuddies.org and then did some more research about this topic on other websites and found some possible ideas under this topic:
  o http://www.sciencebuddies.org/
    ▪ Determine if equivalent amounts of a renewable agrofuel release the same amount of heat energy as a nonrenewable fuel.
  o http://www.juliantrubin.com/
    ▪ Determine how efficient certain biofuels are in comparison to diesel fuel and whether using new or used oil in the making of the biofuels alters their efficiency
    ▪ The Potential for Tree Based Oils As a Substitute for Diesel Fuel
    ▪ A Comparison of Energy Content of Biodiesels Made from Waste Vegetable Oils
    ▪ Maximizing the Production of Ethanol from Corn Starch
    ▪ What Type of Fuel Has the Greatest Energy per Unit Mass?
  o http://www.sciencedaily.com/releases/2015/08/150813123053.htm
    ▪ Timothy Durrett, assistant professor of biochemistry and molecular biophysics, and collaborators at Michigan State University and the
University of Nebraska, Lincoln have modified Camelina sativa -- a nonfood oilseed crop -- and produced the highest levels of modified seed lipids to date. By modifying the oilseed biochemistry in camelina, the researchers have achieved very high levels of an oil with reduced viscosity and improved cold temperature characteristics.

- Relationship between viscosity of oil and viscosity of fuel produced
  - Which Starch Plant Produces the Most Fuel?
  - What type of fuel will give greater power to car
  - Which biofuel produces lower emissions
  - Which has biofuel has higher lubricity

### 27/12/15

- Have decided to do SRP on biofuels
  - Biofuels represent an immense growth opportunity around the world and have an important role to play in displacing the fossil fuels the world has relied upon in the past with a cleaner, renewable alternative.
  - The environmental benefits of biofuel use have been widely documented. The reduction in greenhouse gas emissions resulting from the use of biofuels and biofuel blends is closely aligned with the Government’s “Direct Action” approach to climate change. Australian biodiesel has the potential to reduce emissions by over 85% in comparison to diesel and Australian ethanol can reduce emissions by approximately 50%.
  - Some types of biofuels:
    - Biodiesel:
      - Cooking oil (used and new) e.g. vegetable oil
      - Algae oil
    - Bioethanol:
      - Starch plants e.g. corn, soybeans & sugarcane
      - Cellulose

### 30/12/15

- Some stuff to do with biofuels:
  - Cost efficiency → amount of fuel produced vs. cost
  - Availability of biomass
  - Viscosity of fuel produced → should have low viscosity
  - Energy production

### 31/12/15

- Some biofuel issues:
  - Food vs. fuel:
    - The rising demand for crops for fuel has put them in direct competition with food crops over land and water. With food being burned in our
cars instead of used to feed hungry people, the price of food is being pushed up. Meeting existing European biofuel targets would push the price of some crops up by as much as a third. For poor families in the developing world who have to spend up to 80% of their income on food, even a small rise in the price of staple foods is catastrophic. - https://www.actionaid.org.uk/food-not-fuel/the-problem-with-biofuels

- Algae:
  - One of the major benefits of algae is that they can use a diverse array of carbon sources. Most notably, it has been suggested that algae might be tied directly to carbon emitting sources (power plants, industry, etc.) where they could directly convert emissions into usable fuel. This means that no carbon dioxide would be released from these settings and thus total emissions would be reduced substantially.
  - As with everything, algae have a down side. In this case, the downside is large and if it cannot be solved, is a deal breaker. Algae, even when grown in waste water, require large amounts of water, nitrogen and phosphorus to grow. So much in fact that the production of fertilizer to meet the needs of algae used to produce biofuel would produce more greenhouse gas emissions than were saved by using algae based biofuel to begin with. - http://biofuel.org.uk/third-generation-biofuels.html

- This means that food sources like corn are not great options and new technology needs to be developed to efficiently grow algae
- Became clear that I should use sources that are treated as waste and are abundant e.g. waste cooking oil
- Seems like a good idea to create biodiesel using different waste cooking oils and test which produces most energy and which has lowest viscosity
- Conducted research into best oils to use http://www.wikihow.com/Make-Bio-Diesel:
  - Vegetable
  - Canola
  - Corn
  - Sunflower
- Draft aim: To determine which waste oil (vegetable, canola, corn or sunflower oil) biodiesel produces the most energy and has the lowest viscosity
- Goal was to have decided on SRP idea and aim by today ✔

03/01/16

- Researched about process of making biodiesel from waste cooking oils although they seem rather complicated and extremely dangerous!
- Dangers:
  - Over the years there have been a number of biodiesel processing related accidents and fires, even some serious injuries and a couple of deaths. Making biodiesel is inherently dangerous, you are working with toxic flammable liquids and strong caustics to make fuel. - http://www.make-biodiesel.org/Biodiesel-Safety/biodiesel-safety-tips.html
  - Some of the chemicals are extremely hazardous, explosive and inflammable. This instructable is a video based step by step of a training course but can not be thought of as a substitute for proper hands on training. Please do not attempt to make biodiesel without such training. -

- The risks with making biodiesel seem too large → shouldn’t put my health at risk and I would probably burn down the school
- Considered maybe creating a test where a variable is changed in the earlier stages of this biodiesel process so that the biodiesel wouldn’t actually have to be made, although there isn’t much that can be done
- Will need to change idea :(
- Means that original plans for timeline up until proposal due date probably will not be met

05/01/16

- Considering creating bioethanol instead by fermenting different starch plants and determining which one produces the most energy and which bioethanol produced has the lowest viscosity
- Will need distillation apparatus e.g. a reflux still → looks difficult to make and requires too many materials http://www.instructables.com/id/Building-a-Keg-Still-Bokakob-Design-Reflux-Still/

07/01/16

- Decided not to do bioethanol idea as process is too complicated and like any fuel, ethanol is very volatile and dangerous
- Searched on http://www.education.com/science-fair/ for ideas but found nothing
- Idea of doing something related to solar panels came to mind, e.g. changing the materials to see which one produces the most energy or most efficient

09/01/16

- Have been doing research about solar cells and the different types, e.g. silicon & organic photovoltaics, and how to make them
- Seems quite complicated and difficult to understand
- Don’t think I will do something on this topic

11/01/16

- Idea of making paper or maybe even toilet paper came to mind
- Researched on types of organic paper:
- Ideal to produce paper with waste materials:
  - Primary fibre crops are those crops that are grown for their fibre such as cotton, tree plantations, jute, flax, hemp and kenaf.
Secondary fibre crops such as plantain/banana, sugar cane, cereals, palm oil and tobacco are not grown for their fibre but rather for their fruit, sap, seed, oil and leaves respectively. - http://www.papyrusaustralia.com.au/why-banana-palm/

Waste from banana plants seem to be good sources for creating paper products:
- The structure of the banana tree trunk is such that individual fibres, which are extremely long and strong, extend from the base of the stem through the entire trunk. This creates a product that is stronger and more durable than traditional forest wood products. Preserving the natural structure of the fibre is the key to producing a high quality end product, which are naturally fire retardant, water repellent and UV resistant. - http://www.papyrusaustralia.com.au/why-banana-palm/

Possible aim: To determine which part of the banana plant (pseudostem, leaf or peel) produces paper with (some sort of properties that are necessary for paper)

13/01/16

- Having difficulty finding out how to make paper from banana fibre without using large machinery
- Researched about ways to extract banana fibres:
  - Many videos show machines that easily extract them
  - The extraction can be done mainly in three ways: Manual, chemical and Mechanical. Of these, mechanical extraction is the best way to obtain fiber of both good quality and quantity in an eco-friendly way. - http://www.bananafibre.com/bananafibre.html
  - Manual way: Banana fibre is generally extracted through a cumbersome manual process. By using a metal scraper (flat and blunt blade), the pseudostem sheaths are scraped and the fibre is separated. - http://www.thehindu.com/todays-paper/tp-national/tp-kerala/easy-way-to-extract-banana-fibre/article3618460.ece
  - Chemical way: by retting
    - Plant material needs to be cooked in alkaline solution to remove lignins from the cellulose pulp. - http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p014.shtml#procedure
    - Fibers need to be cooked in an alkali solution - http://www.missioncreekpress.com/index_files/plants.htm
    - For chemical retting solutions of different chemicals are used, e.g. sodium hydroxide, sodium carbonate, soaps, or mineral acids. - http://cdn.intechopen.com/pdfs_wm/44744.pdf
- Will likely use retting for this

15/01/16

- There is an issue with finding the different parts of banana plant → can’t be bought online or in shops
- Research showed indication of just how much banana is needed:
  - In order to have enough bast fiber to make paper, you need to harvest at least five or six branches that are approximately five or six feet long. This will
yield approximately one pound of bast fiber, which will produce about thirty sheets of paper that are 8-1/2" x 11".

- With any leaf fiber, you will need to harvest at least one pound of dry fiber in order to have enough leaves to make a small amount of paper. The dry weight is tricky to determine if you are collecting fresh leaves—I usually collect three times more fiber than I think I will need. One pound of dry leaf fiber will yield approximately fifteen sheets of 8-1/2" x 11" paper. - http://newsletter.handpapermaking.org/beginner/beg72.htm

- Dad rang up one of his clients to ask if he knew anyone growing banana plants
  - Unable to find anyone with banana plants
  - Client grows sugarcane though
  - Have now decided to switch to sugarcane leaves, which I can acquire
  - Sugarcane leaves are also waste products which contain fibre
- Won't be able to use banana at all as it is too hard to obtain
- Need to find more plants that are easily accessible and available
- Mum suggested using corn husks → can get from Flemington Markets
  - Corn husks are also waste products
  - Found video of paper being made from corn husks: https://www.youtube.com/watch?v=0Na-d0IPpjc
- Continued researching for waste products and found bagasse
  - Dad will ask shops that squeeze sugarcane juice to see if we can get bagasse
- All different types of fibres:
  - Corn husk: grass fibres
  - Sugarcane leaves: leaf fibres
    - Fibres extracted from the leaves are rough and sturdy and form part of the plant's transportation system - http://www.fao.org/docrep/007/ad416e/ad416e06.htm
  - Bagasse fibres
- Still need to determine what paper properties will be tested

18/01/16

- List of some different properties of paper http://www.paperonweb.com/paperpro.htm:
  - Physical:
    - Caliper/thickness
    - Curl
    - Friction
    - Smoothness
    - Roughness
  - Optical:
    - Brightness
    - Whiteness
    - Colour
    - Fluorescence
    - Gloss
    - Opacity
o Strength:
  - Bursting strength
  - Folding endurance
  - Hardness
  - Softness
  - Stiffness
  - Tearing resistance / tear factor / tear index
  - Tensile strength / tensile index
  - Wet strength

o Misc.:
  - Dirt content
  - Permanence & durability
  - Porosity
  - Air resistance

20/01/16

- Decided I need to practise making paper with recycled paper first to get experience
- Researched equipment/materials and process
- Will need to buy some equipment/materials to make this paper-based paper (this is not the equipment list for the plant-based paper)
- Equipment/materials already owned:
  - 5 x A4 sheets of recycled paper
  - 1 x paper shredder
  - 1 x power socket
  - 1 x hammer
  - 20 x tacks
  - 1 x blender
  - Water
  - 1 x stopwatch
  - 1 x measuring cup
  - Heavy box of books
- Equipment/materials I need to buy:
  - 2 x approx. A4 sized identical wooden photo frames
  - 1 x sponge
  - 1 x large plastic container (top greater than A4 sized)
  - Fibreglass screen to fit frame
  - 10 x felt sheets
- Will go to Bunnings and a 2$ shop on 23/01 to buy materials

22/01/16

- Bought 3 sponges from Woolworths today

23/01/16
• Bought 1m of fibreglass screening and 10 sheets of felt from Bunnings
• Couldn’t go to 2$ shop today → will go tomorrow
• Mum brought back a box of corn husks when she went to Flemington Markets today

25/01/16

• Researched some of the different properties & ways to test them to begin cutting down list to some that are worth testing/will be able to test:
  o Physical:
    ▪ Caliper/thickness
    ▪ Smoothness/roughness
  o Optical:
    ▪ Whiteness
    ▪ Opacity
  o Strength:
    ▪ Bursting strength
    ▪ Folding endurance
    ▪ Stiffness
    ▪ Tearing resistance / tear factor / tear index
    ▪ Tensile strength / tensile index
    ▪ Wet strength
  o Misc.:
    ▪ Porosity

26/01/16

• Dad couldn’t find tacks so went to Bunnings to buy drawing pins instead
• Hammer won’t be needed anymore
• Wrote up a risk assessment for making this paper-based paper:

Activity description:
This activity involves making paper by pulping recycled waste paper and lifting the pulp onto a mould and deckle to create a sheet.

<table>
<thead>
<tr>
<th>Step 1: Identify the hazard</th>
<th>Step 2: Strategies to minimise the hazard</th>
<th>Step 3: Assessment of risk (see table below)</th>
<th>Step 4: What if something goes wrong?</th>
<th>Step 5: Packing up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glassware can break and cause cuts</td>
<td>Place glassware away from edges of benches and keep outside dry to minimise slipperiness</td>
<td>1 + 2 = 3 = MODERATE</td>
<td>In case of breakage consult an adult. Empty glassware, brush up and place in ‘broken glass’ bin. Wipe up any spills.</td>
<td>Clean, dry and pack away carefully</td>
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12 •
<table>
<thead>
<tr>
<th>Bladed Equipment</th>
<th>Preventive Measure</th>
<th>First Aid Action</th>
<th>Action to Take After Use</th>
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<tbody>
<tr>
<td>Blades of scissors can cause cuts and injuries.</td>
<td>Face scissors away from the body when in use, do not run with scissors.</td>
<td>Close blades of scissors and seek first aid.</td>
<td>Close blades of scissors after use and pack away.</td>
</tr>
<tr>
<td>Sharp point of drawing pins can cause cuts and injuries.</td>
<td>Keep point of pins away from the skin and ensure the box is away from edges of bench to prevent pins from dropping on the floor.</td>
<td>Seek first aid.</td>
<td>Ensure all unused pins are placed back in packaging, which should be sealed shut.</td>
</tr>
<tr>
<td>Blades of paper shredder can cause cuts and injuries.</td>
<td>Keep fingers away from opening of paper shredder and feed in paper by holding it from the top.</td>
<td>Turn off paper shredder and unplug from power socket immediately. Consult an adult and seek first aid.</td>
<td>Turn off paper shredder and unplug from power socket immediately after use.</td>
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</table>

Mandatory precautions: Covered shoes, safety glasses, hair exceeding shoulder length tied back.

Date: 26/01/16 Student Signature: Sherie Pan

- Made the mould and deckle:
  1. The backing material and glass were removed from two 20cm x 25cm wooden photo frames.
  2. Using a ruler, a 24cm x 29cm piece of fibreglass screen was measured and cut out using scissors.
  3. The piece of fibreglass screen was placed over the face of one of the frames so that it was taut.
  4. The edges of the fibreglass screen were folded over the sides of the frame and tacked into place using five drawing pins on each side of the frame.
  5. The frame with the screen attached was the mould, and the other, empty, frame was the deckle.

- References for method to make paper:
  - [https://www.youtube.com/watch?v=fyr24PgpDDs](https://www.youtube.com/watch?v=fyr24PgpDDs)
  - [http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p014.shtml#procedure](http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p014.shtml#procedure)
  - [http://www.wikihow.com/Make-Paper](http://www.wikihow.com/Make-Paper)
27/01/16

- Made the paper:
  1. Five A4 sheets of recycled paper were shredded in a paper shredder and separated into two equal piles.
  2. The shredded pieces of paper were torn into smaller pieces approximately three times smaller.
  3. Using a measuring cup, 1L of water was added into the blender along with one pile of paper shreds.
  4. The mixture was blended on low for 40 seconds and then medium for 20 seconds, timed using a stopwatch.
  5. The blended pulp was poured into the storage container.
  6. Steps 3-5 were repeated with the remaining half of the shredded paper.
  7. 2L of water was measured and added to the storage container.
  8. The mixture was stirred gently with the hand to lift the pulp that had settled on the bottom of the container.
  9. The deckle was placed on top of the mould, with the smooth side of the deckle facing down, and the screen-side of the mould facing up.
  10. The mould and deckle were held horizontally and fully submerged into the container, then slowly lifted out so that the pulp formed a film across the screen.
  11. The mould and deckle were held above the container to let the excess water drain until it was no longer dripping.
  12. The deckle was removed from the mould and replaced with a felt sheet.
  13. The mould was flipped upside down so that the felt sheet was on the bottom.
  14. A sponge was used to press onto the screen to remove the remaining excess water until no more water came out.
  15. The mould was slowly and carefully removed from the felt sheet so that the paper remained on the felt.
  16. Another piece of felt was placed on top of the piece of paper.
  17. Steps 8-16 were repeated four times.
  18. All the felt sheets were placed underneath a box of heavy books for four hours to press the sheets of paper.
  19. The top sheet of felt was removed from all five pieces of paper.
20. The pieces of paper were placed in front of a fan on high for two hours to speed up the drying process. 
21. The top sheets of felt were placed back onto the pieces of paper and placed underneath the box of books for another seven hours.

The pulp formed a sheet of paper on the mould

The shredded paper and water were blended

A sponge was used to remove the remaining excess water

- Very difficult to remove mould from paper without breaking the paper → could slide a sharp knife under paper next time or make sure paper has less water
- Broke the paper on the first 2 tries and put the pulp back in the container to do it again
- Enough to make 5 sheets of paper
- Paper seemed to get a little thinner towards the end → instead should start with the same amount of pulp and water each time a new sheet of paper is made
- Need a better way to dry paper

28/01/16

- Paper was removed from underneath box
- Seems quite thick and strong

Continued cutting list of properties:

  - Physical:
    - Smoothness/roughness
  - Optical:
    - Brightness
  - Strength:
    - Bursting strength
    - Folding endurance
    - Tearing resistance
- Tensile strength
- Wet strength
  - Misc.: Porosity
- Having a lot of difficulty choosing which properties to test as there is little information on the internet describing how to conduct the testing of many properties because it is usually done by professional companies and the methods are not disclosed.

**30/01/16**

- Incomplete equipment list for SRP:
  - Corn husks
  - Sugarcane leaves
  - Bagasse
  - 1 x scissors
  - 1 x pair of rubber gloves
  - 1 x safety glasses
  - 1 x lab coat
  - 1 x electronic balance
  - 1 x large stainless steel cooking pot
  - 1 x stove
  - 1 x spoon
  - Sodium carbonate (soda ash)
  - 1 x measuring cylinder
  - 1 x phone alarm
  - 1 x 26x56cm net bag
  - 1 x pH meter
  - 2 x identical 20x25cm wooden photo frames
  - 1 x 24x29cm sheet of fibreglass screen
  - 20 x drawing pins
  - 1 x ruler
  - 1 x blender
  - 1 x power socket
  - 1 x stopwatch
  - Tap water
  - 1 x 1L beaker
  - 1 x 15L storage container
  - 1 x sponge
  - 10? x felt sheets
  - Heavy box of books?
  - Fan?
  - Hairdryer?
  - Thermometer?
- Equipment I don't have yet:
  - Sugarcane leaves & bagasse → will collect from dad’s client/shop closer to when I conduct trials
  - Safety glasses, lab coat, sodium carbonate, pH meter → will see if I can borrow from school
  - Equipment that will be needed to test the properties of the paper → will likely borrow from school
31/01/16

- Goal was to have collected all equipment that I can acquire by myself (not equipment that I may borrow from school) by today ✓
- Looked at corn husk paper video again to help decide quantities for method https://www.youtube.com/watch?v=0Na-d0IPpjC
  - 19L of water | 2 pounds of corn husk | 20 (15mL x 20) tablespoons of soda ash (1 per qt. of water) | cook for 2 hrs → produced significant amount of paper
  - Will probably cut down to: 6L water | 300g corn husk | 90mL soda ash

01/01/16

- Shared logbook with teacher and emailed her:
  Hi (teacher)
  My idea for my SRP is based around using waste materials to create paper, as paper made from wood has numerous problems, including cutting down trees and the fact that it is a significant contributor to landfill waste. So I have decided to use corn husk, sugarcane leaf and bagasse to create paper, which will be more biodegradable as it is made from biological material and also helps to recycle waste.
  I would like to test some properties of the paper that will be made, but currently I am sort of stuck in deciding which paper properties to test as there is such a large variety and many are useful for different types of paper like printing paper, cardboard, paper bills etc. So far I'm thinking of choosing from:
  - Smoothness/roughness
  - Brightness
  - Bursting strength
  - Folding endurance
  - Tearing resistance
  - Tensile strength
  - Wet strength
  - Porosity

  Another problem is that the methods for testing these properties are generally done using very technical equipment/machinery and the methods are usually done by professional companies who don't disclose their methods. So I am not sure how I can test these properties in a simpler way.

  Do you have any suggestions for any other things I can do with this paper?

  Hi Sherie,
  Very impressive work. You have put in a great deal of effort here. The paper looks very good.
  My concerns are around the purpose of the investigation. Paper made from wood is very biodegradable and breaks down in landfill quite easily. So, I am not sure that your paper would be beneficial in this regard.
  The measurement of the properties of your paper is posing difficulties and I suspect the corn/sugar cane paper would always be inferior to the paper made from wood. I am wondering if the bagasse and leaves could be used for something else.
Would your project have a real world application?
Keep thinking…

- The background research wasn’t phrased very well and is not exactly right

03/02/16

- Talked to teacher in class
- Realised that the focus/purpose is to do something with recycling the waste materials of sugarcane juice shops/farmers/markets etc. rather than having them to throw it into landfill
- Suggested that I try and see if the waste can be used for other purposes as handmade paper isn't comparable with commercially made paper

04/02/16

- Did some research to find alternative use of fibres → clothing etc. → nothing I can make
- Decided that it is still better to make paper → doesn’t necessarily be have to be copy/writing paper → packaging paper?

05/02/16

- Talked to teacher again
- Discussed independent variable → suggested that I change something in method of creating paper → e.g. amount of each material like 50% leaf, 40% leaf, 30% leaf etc.
- Discussed how many times I should repeat method → aim would be 20 times → seems unlikely as process is extremely long
- Cut to 3L water | 100g corn husk | 30mL soda ash
- Thinking of doing 100% bagasse paper; 100% corn husk paper; 100% sugarcane leaf paper; and ⅓ bagasse, ⅓ corn husk, ⅓ sugarcane leaf blend paper

06/02/16

- Went to dad’s client’s house to collect sugarcane leaves and collected some more corn husk
- Worked on proposal: background research, risk assessment, equipment, timeline
- Decided to 'size' the paper to reduce water absorptivity → need to buy gelatine

07/02/16

- Bought gelatine from Coles
- Decided that dependent variables will be tensile strength, wet strength and stretch for now
- Finished rest of proposal
BACKGROUND RESEARCH

Crop residue is the waste plant material that remains after harvest, including leaves, stalks, husks and stems. Traditionally, most of this crop residue is burnt or thrown into landfill to rot, in both ways contributing to air pollution and climate change by releasing greenhouse gases such as carbon dioxide and methane, which is 27 times more dangerous to the ozone than carbon dioxide (Using Bagasse for Bioenergy, 2014). Crop residue burning helps growers stay competitive as it is an inexpensive and effective method to remove excess residue (McCarty, 2014), whilst assisting in weed, insect and disease control. However, crop residue burning has significant long-term disadvantages, such as contribution to air pollution, reduction in soil structure, loss of soil nutrients and carbon, impact on soil microbes and fauna, increased soil acidity, and increase in erosion (Agriculture.vic.gov.au, 2015).

Rather than disposing of crop residue in ways that have detrimental impacts on the environment, these waste byproducts can instead be recycled and utilised in the production of paper, whilst also conveniently helping farmers discard their waste. Paper is formed by a network of cellulosic fibres (Schmied et al., 2013), which can be obtained from plant-based material. These fibres can be converted into pulp by two processes, chemical pulping or mechanical pulping. The pulp can then be transferred onto screens to form paper, while additives can be included as required to enhance certain properties of the paper.

Strength is an important property of paper, particularly packaging papers, as it is ideal for paper to retain its form and be resistant to tear and other external factors that may cause damage. Tensile strength is paper’s ability to withstand a stretching force, wet strength indicates the strength paper retains after it has been saturated with water (Printwiki.org, 2016), and stretch refers to maximum length paper can be stretched without breaking when under tensile stress (Paperonweb.com, 2016). Handmade papers are typically characterised by a lack of grain direction due to dispersed fibres, thus giving it comparatively greater strength (Handmadepaper-products.com, 2016).

Sugarcane and maize (corn) waste is copious, being the top two crops with the greatest global production, with 1,877,110,000 tonnes of sugarcane and 1,016,740,000 tonnes of maize harvested in 2013 (Faostat.fao.org, 2014). Bagasse is the fibrous waste material that remains after sugarcane stalks are squeezed to extract juice for consumption. (Using Bagasse for Bioenergy, 2014). Sugarcane leaf is a type of leaf fibre and is waste material from the sugarcane plant. Currently only 50% of the cane biomass available for use is collected (Using Bagasse for Bioenergy, 2014). Corn husk is the leafy outer shell that covers an ear of maize (corn) as it grows on the plant.

Moreover, by producing more paper from agricultural waste, this will yield further benefits, as the need to cut down trees in order to produce paper will be diminished, thus helping to alleviate the environmental concerns over unsustainability in regards to deforestation. 42 percent of global wood harvest is used to produce paper, and paper products represent one of the greatest components of landfills, accounting for a third of municipal waste (The World Counts, 2014). Currently, alternative fibres only account for less than 10 percent of fibre in paper and packaging (GreenBiz, 2011). Research and development into the use of crop residue, a promising alternative, is continually being extended today, with a growing number tree-free paper products emerging on the market.
RELIABILITY OF SOURCES


The reliability of this source is very high as it is on a reputable site (.org) and is current (last updated 19/02/2015). Furthermore, it has been written by a qualified person with extensive scientific background, Dr. Andrew Olson.

Dr. Andrew Olson was Senior Scientist at Science Buddies for two years, during which time he authored and edited hundreds of project ideas for the website. Andrew is a neuroscientist by training, with a Ph.D. in Neuroscience from the University of Pennsylvania, and an A.B. in Classics-Latin from Harvard College. He is now the director of the imaging core facility for the Neuroscience Institute at Stanford University.

The information regarding equipment and method is presented in an objective manner without bias. Moreover, the papermaking information presented in this source can be substantiated in a large number of other sources, such as https://www.exploratorium.edu/exploring/paper/handmade2.html, making it highly accurate. A reference is also made to statistics sourced from the U.S. Energy Information Administration, a reputable source, although there is no evidence that this data had been collected from any valid first-hand investigations.


The reliability of this source is quite high as it is on a reputable site (.org.au). The exact author is not specified, however the information is highly likely to have been written by an employee for Clean Energy Council and that data would probably have been checked and edited. The date that this factsheet was published is also unspecified, although this was a link for further reading on a Clean Energy Council page published in 2014; therefore it is most likely that this factsheet would have still been relevant to 2014, which is relatively current. The factsheet refers to a variety of data and statistics, although it is not clear whether this has been sourced from valid first-hand investigations. Most of this data can be substantiated in other sources though, so it should be relatively accurate. The information presented is not entirely objective, as it only engages with information regarding the benefits of using bagasse. However, the information is written in a factual and informative manner without the use of emotion to sway belief.


The reliability of this source fairly high as it is on a somewhat reputable site. Although it is not a .gov or .edu site, it is still a widely-used site by teachers, students and parents for educational purposes. The information was published not too long ago in 2013 and was written by a qualified person with expertise in the field of science, Erin Björnsson. Björnsson graduated with a Bachelor of Science, Chemical Engineering from the University of 20 •
California and is currently a senior process engineer at ENOVIX Corp.. The information presented is factual and objective without any bias. In addition, Mamata Adhikary, a graduate of the University of Calcutta, commented saying that the information was ‘good’, and Gautam Gupta Rauniyar, a Site Manager at Civil Engineering, with experience in science commented ‘It’s good procedure for tensile strength’. These comments of approval provide some help to increase the accuracy of the information. However, this source does not refer to any data or statistics at all and provide no evidence of sourced information from valid first-hand investigations.

AIM

To determine which type of crop residue paper: sugarcane leaf, bagasse, or corn husk, has the highest tensile strength, wet strength and stretch.

HYPOTHESIS

The bagasse paper will have the highest tensile strength, wet strength and stretch.

EQUIPMENT

- 2 x identical 20x25cm wooden photo frames
- 1 x 24x29cm sheet of fibreglass screen
- 20 x drawing pins
- 2 x 30cm rulers
- 1000g corn husks
- 1000g sugarcane leaves
- 1000g bagasse
- 1 x scissors
- 1 x pair of rubber gloves
- 1 x safety glasses
- 1 x lab coat
- 1 x electronic balance
- 3 x 5L stainless steel cooking pots
- 3 x gas stoves
- 1 x glass thermometer
- 1 x exhaust hood
- 1 x wooden spoon
- 900mL sodium carbonate
- 1 x 100mL measuring cylinder
- 1 x phone alarm
- 1 x tongs
- 1 x 26x56cm net bag
- 1 x pH meter
- 1 x calculator
- 1 x blender
- 1 x power socket
- 1 x stopwatch
- Access to tap water
- 240g McKenzie’s Baking Aids Gelatine
### RISK ASSESSMENT

**Activity description:**
This activity involves creating pulp by retting and blending corn husk, sugarcane leaf and bagasse in order to produce paper. This paper will be tested for tensile strength, wet strength and stretch.

<table>
<thead>
<tr>
<th>Step 1: Identify the hazard</th>
<th>Step 2: Strategies to minimise the hazard</th>
<th>Step 3: Assessment of risk (see table below)</th>
<th>Step 4: What if something goes wrong?</th>
<th>Step 5: Packing up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glassware can break and cause cuts</td>
<td>Place glassware away from edges of benches and keep outside dry to minimise slipperiness</td>
<td>$1 + 2 = 3 = \text{MODERATE}$</td>
<td>In case of breakage consult an adult. Empty glassware, brush up and place in 'broken glass' bin. Wipe up any spills. If cuts occur, seek first aid.</td>
<td>Clean, dry and pack away carefully</td>
</tr>
<tr>
<td>Blades of scissors can cause cuts and injuries</td>
<td>Face scissors away from the body when in use and do not run with scissors. Ensure gloves are worn when cutting plant material</td>
<td>$1 + 1 = 2 = \text{LOW}$</td>
<td>Close blades of scissors and seek first aid.</td>
<td>Close blades of scissors after use and pack away.</td>
</tr>
<tr>
<td>Sharp point of drawing pins can cause cuts and injuries</td>
<td>Keep point of pins away from the skin and ensure the box is away from edges of bench</td>
<td>$1 + 2 = 3 = \text{MODERATE}$</td>
<td>Seek first aid.</td>
<td>Ensure all unused pins are placed back in packaging, which should</td>
</tr>
<tr>
<td>Hot flame can cause burns</td>
<td>Keep skin and face away from flame at all times. Wear gloves</td>
<td>2 + 1 = 3 = MODERATE</td>
<td>Turn off flame immediately. Run burned area under cold water. Consult an adult and seek first aid</td>
<td>Turn off flame immediately after use</td>
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<tr>
<td>Flame may catch other objects on fire</td>
<td>Keep pot placed on open flame at all times. Keep all other objects away from stove top</td>
<td>2 + 1 = 3 = MODERATE</td>
<td>Turn off flame immediately. Place ignited object in kitchen sink and run under cold water immediately, or use a fire extinguisher. Consult an adult.</td>
<td>Turn off flame immediately after use</td>
</tr>
<tr>
<td>Hot water can cause burns</td>
<td>Ensure that pots are stable when sitting on stove tops at all times. Keep hands away from water at all times and wear gloves</td>
<td>2 + 1 = 3 = MODERATE</td>
<td>Run burned area under cold water. Consult an adult and seek first aid</td>
<td>Carefully pour hot water into sink and run pot under cold water immediately after use</td>
</tr>
<tr>
<td>Hot pots can cause burns</td>
<td>Ensure that pots are stable when sitting on stove tops at all times. Keep hands away from metal areas of pot at all times and wear gloves. Only carry the pots by the handles</td>
<td>2 + 1 = 3 = MODERATE</td>
<td>Run burned area under cold water. Consult an adult and seek first aid</td>
<td>Run pot under cold water immediately after use. Clean, dry and pack away</td>
</tr>
<tr>
<td>Prolonged exposure to sodium carbonate may cause irritation to skin and eyes. Ingestion can be</td>
<td>Keep sodium carbonate away from face at all times. Ensure lab coat, gloves and safety goggles are worn when handling</td>
<td>2 + 1 = 3 = MODERATE</td>
<td>Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes. Consult adult and seek medical attention. Skin Contact: Immediately flush skin with plenty of</td>
<td>Ensure lid of container storing sodium carbonate is closed tightly immediately after use. Clean up any spills and wipe bench with</td>
</tr>
<tr>
<td>Hazardous and Inhalation may cause lung irritation</td>
<td>Sodium carbonate</td>
<td>Water. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Consult adult and seek medical attention. Seek fresh air if inhaled. Consult adult and seek medical attention if inhaled or ingested</td>
<td>Paper towel and gloves.</td>
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<tr>
<td>Contents of blender may come out of the blender whilst being processed and cause injuries</td>
<td>Ensure the lid is placed firmly on the blender while in use. Ensure safety goggles and lab coat are worn.</td>
<td>$1 + 1 = 2 = \text{LOW}$</td>
<td>Turn off blender immediately and clean up spills. If contents come into contact with eyes, flush eyes immediately with plenty of water, consult an adult and seek first aid</td>
<td></td>
</tr>
<tr>
<td>Bulldog clip may cause injuries</td>
<td>Keep fingers and skin away from clamp of bulldog clip at all times</td>
<td>$1 + 1 = 2 = \text{LOW}$</td>
<td>Seek first aid</td>
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<tr>
<td></td>
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<td>Ensure bulldog is closed after use</td>
<td></td>
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</tbody>
</table>

Mandatory precautions: Covered shoes, safety glasses, hair exceeding shoulder length tied back.

Date: 07/02/16  
Student Signature: Sherie Pan

**METHOD**

Making the Mould and Deckle:

1. The backing material and glass were removed from two 20cm x 25cm wooden photo frames.
2. Using a ruler, a 24cm x 29cm piece of fibreglass screen was measured and cut out using scissors.
3. The piece of fibreglass screen was placed over the face of one of the frames so that it was taut.
4. The edges of the fibreglass screen were folded over the sides of the frame and tacked into place using five drawing pins on each side of the frame.
5. The frame with the screen attached was the mould, and the other, empty, frame was the deckle.

Preparing the Crop Residue:

6. All windows were opened to ensure adequate ventilation.
7. 100g of sugarcane leaves were weighed on the electronic balance.
8. Using scissors and a ruler, the sugarcane leaves were cut into pieces where the length of the pieces parallel to the fibres was 6cm.
9. Using the beaker, 3L of water was added to a pot.
10. The sugarcane leaves were soaked in the pot of water for 2 hours and the timer was set.
11. The sugarcane leaves were removed from the pot and rinsed thoroughly with tap water.
12. The pot emptied into the sink and refilled with 3L of water and placed on top of the stove.
13. Using the measuring cylinder, 30mL of sodium carbonate was added carefully to the pot and stirred with the wooden spoon to create an alkaline solution.
14. The stove was turned on high to boil the water and the exhaust hood was turned on.
15. Once the water reached 100 degrees celsius, measured using the thermometer, the stove was turned on low and the sugarcane leaves were added to the pot and cooked to remove the lignins. A timer was set for 3 hours.
16. The stove and exhaust hood were turned off and the pot was allowed to cool for 10 minutes.
17. Using tongs, the sugarcane leaves were removed from the pot and placed into the net bag.
18. The sugarcane leaves were rinsed thoroughly under tap water whilst suspended in the net bag.
19. The pot was emptied and refilled with 3L of tap water and the pH of the water was tested.
20. The net bag with the sugarcane leaves was placed into the pot of water and the pH was tested. If the pH was not same as the original reading of the tap water, the sugarcane leaves were rinsed again and the pH of them whilst suspended in water was measured again until it matched the original pH.
21. Steps 7-20 were repeated with the bagasse and corn husks.

Making the Pulp:
22. The cooked sugarcane leaves were weighed on the electronic balance and separated into 4 piles of equal weight, calculated using the calculator.
23. 200mL of water was added to the blender along with one pile of sugarcane leaves.
24. The mixture was blended on low for 40 seconds and then medium for 20 seconds, timed using a stopwatch.
25. The blended pulp was poured into the storage container.
26. 2L of water was measured and added to the storage container.
27. 2g of gelatine was dissolved in 20mL of hot tap water and added to the storage container.
28. The mixture was stirred gently with the wooden spoon to lift the pulp that had settled on the bottom of the container.

Making the Paper:
29. The deckle was placed on top of the mould, with the smooth side of the deckle facing down, and the screen-side of the mould facing up.
30. The mould and deckle were held horizontally and fully submerged into the container, then slowly lifted out so that the pulp formed a film across the screen.
31. The mould and deckle were held above the container to let the excess water drain until it was no longer dripping.
32. The deckle was removed from the mould and replaced with a felt sheet.
33. The mould was flipped upside down so that the felt sheet was on the bottom.
34. A sponge was used to press onto the screen to remove the remaining excess water until no more water came out.
35. The mould was slowly and carefully removed from the felt sheet so that the paper remained on the felt.
36. Another sheet of felt was placed on top of the paper.
37. Using the mould, the excess leaf fibres were removed from the water in the container and thrown into the rubbish bin.
38. The water in the container was poured into the sink.
39. Steps 23-38 were repeated with the other 3 piles of sugarcane leaves.
40. The felt sheets and paper were placed under a heavy box of books for 1 hour.
41. The felt sheets were removed from underneath the box and the top sheet of felt was removed from each piece of paper.
42. The pieces of paper were placed on the ground 30cm away from the fan, which was turned on high for 3 hours.
43. The top sheets of felt were placed back onto the pieces of paper and placed underneath the box of books for 1 hour.
44. The felt sheets were removed from underneath the box and the pieces of paper were removed from the felt sheets.
45. Steps 22-44 were repeated with the bagasse and corn husks.

Cutting the Paper:
46. Using scissors and a ruler, all pieces of paper were cut into strips measuring 5cm by 20cm.

Setting Up Paper Testing:
47. The top of the spring balance was taped firmly to the wall using sticky tape.
48. The rings of the bulldog clip were flipped up and hung onto the hook of the spring balance.
49. The 2 rulers were taped on the wall underneath the spring balance so that the second ruler followed on after the 30cm of the first ruler.
50. The phone was set up on the tripod and slow motion recording app was opened and started recording the wall, ensuring the rulers were in shot.

Testing Tensile Strength and Stretch:
51. One strip of sugarcane leaf paper was clamped into the bulldog clip, with the 5cm edge being clamped.
52. The piece of paper was slowly pulled downwards until it was torn.
53. The video recording was played back to determine the force taken to break the piece of paper by examining the reading on the spring balance at the moment of breakage.
54. The stretch was determined by playing back the video recording to examine the length of the piece of paper against the rulers right before the moment of breakage. The stretch percentage was calculated by doing: 1 - (20 / new length) x 100.
55. Steps 51-54 were repeated with 5 more strips of sugarcane leaf paper.
56. Steps 51-55 were repeated with the bagasse and corn husk paper.

Testing Wet Strength:
57. A pot was filled with 500mL of water.
58. 6 strips of sugarcane leaf paper were placed into the water for 10 minutes.
59. Steps 51-53 were repeated with all 6 strips of sugarcane leaf paper.
60. Steps 57-59 were repeated with 6 strips of bagasse paper and 6 strips of corn husk paper.

61. Steps 1-60 were repeated 9 times.
EVALUATION OF METHOD

This method is valid for investigating the selected hypothesis as it uses appropriate measuring procedures to determine the tensile strength, wet strength and stretch of the papers to be produced, thus allowing a comparison of these properties for the three different types of crop residue paper. The basic methods for preparing the crop residue, creating the pulp and paper, and testing the three paper properties have been substantiated in more than one secondary source, so they are of a high accuracy. The proposed method incorporates the use of suitable equipment such as a graduated measuring cylinder, beaker, spring balance and rulers to enhance the precision of the measurements that will be taken. Furthermore, a significant number of variables throughout this method have been taken into account to ensure that they are controlled to strengthen the reliability of the results. An example of this is the size of each strip of paper (measured using a ruler) that will undergo testing for the three paper properties. Therefore, this method is valid as it will allow measurements to be taken that will correspond to that data that is intended to be measured, being the tensile strength, wet strength and stretch of the papers to be produced.

VARIABLES

Independent:
- Type of crop residue the paper is made from

Dependent:
- Tensile strength of the paper
- Wet strength of the paper
- Stretch of the paper

Controlled:
- Preparation method of each type of crop residue:
  - Size of pieces of crop residue
  - Cooking time
  - Amount of water and sodium carbonate
  - pH of cooked fibres
- Pulp-making method of each type of crop residue:
  - Amount of fibres and water in blender
  - Blending time
  - Amount of water, pulp and gelatine in storage container for each sheet of paper made
- Papermaking method for each type of crop residue:
  - Same mould and deckle used to make each piece of paper
  - Size of each piece of paper made
  - Drying time, conditions and method of paper
- Method of testing tensile strength, wet strength and stretch for each type of crop residue paper:
  - Size of each strip of paper
  - Use of same spring balance
  - Same slow motion recording app to record each test
  - Amount of time strips of paper are left in water for
  - Same rulers to measure each piece of paper when testing stretch
### TIMELINE

#### FEBRUARY

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<td>8</td>
<td>Proposal due</td>
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<td>Ensure all equipment needed for trial has been collected</td>
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<td>Continue conducting trial</td>
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<td>15</td>
<td>Begin writing findings of trials</td>
<td>16</td>
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<td>Finalised adjustments that will be made to experiment</td>
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<td>Conduct test #1 &amp; #2</td>
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<td>23</td>
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<td>Log containing trials due</td>
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<td>Conduct test #4 &amp; #5</td>
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#### MARCH

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### MARCH

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<tr>
<td>6</td>
<td>Conduct test again if necessary</td>
<td>7</td>
<td>8</td>
<td>Conduct test again if necessary</td>
<td>9</td>
<td>10</td>
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<td>Begin to write up report (first half of report likely taken from proposal)</td>
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<td>Conduct test #10 and anymore tests if necessary</td>
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<td>12</td>
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<td>Conduct writing up results → tables, graphs etc.</td>
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28 •
<table>
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<tr>
<th>13</th>
<th>14</th>
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<th>16</th>
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<th>19</th>
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<tbody>
<tr>
<td>Begin writing discussion</td>
<td>Review parts from proposal to see if anything needs to be changed</td>
<td>Finish discussion and write conclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>20</th>
<th>21</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edit and review report</td>
<td>Finish editing and formatting report</td>
<td>SRP final report &amp; log due</td>
</tr>
</tbody>
</table>

**BIBLIOGRAPHY**


**13/02/16**

- Unable to start testing this weekend as proposal has not been handed back back yet

**14/02/16**

- Collected bag of bagasse from nearby restaurant
- Must use rice bags to store bagasse otherwise infestations of ants will be attracted
- From looking at all three crop residues together, it seems that sugarcane leaves will produce paper with the most strength → bagasse is shredding and pieces are flying everywhere, corn husk is very flexible

**15/02/16**

- Proposal handed back → need to rewrite hypothesis:
  - The bagasse paper will have the highest tensile strength, wet strength and stretch.
  - The bagasse paper will have the highest tensile strength, wet strength and stretch than the sugarcane leaf paper and corn husk paper.

**20/02/16**

- Bought washing soda (sodium carbonate) from Woolworths today
- Began trials
• Need to add to equipment: 3 buckets, gardening scissors (use to cut plants with instead of normal scissors → much easier this way), gardening gloves, change sodium carbonate to ‘Lectric Washing Soda’
• Realised that I can’t measure the different crops by weight as I had planned to, since sugarcane leaf is a lot lighter than bagasse, meaning there would be a significantly greater amount of sugarcane fibre than bagasse fibre for the same weight. Instead, I filled identical plastic boxes with each material after it had been soaked in water so that I had the same volume of fibres. I also used an equal no. of cups to control the amount of fibre for each plant material being added to the blender instead of weighing it.

Using standard cup to measure amount of cooked fibre

Using plastic boxes to measure amount of plant fibre
• Bagasse had disgusting odour after rice bags were opened as the smell had been trapped inside → left the bags open for rest of day and luckily no ants came and smell diminished, smell also disappeared after being soaked in water
• It is more effective and convenient to soak the plants in buckets rather than pots, as the buckets are larger and this means that the pots don’t have to be emptied and cleaned as they would have had to if I was soaking the plants in the pots before they were to be cooked in the pots.
• Started trials with sugarcane leaves:
  o Soaked in buckets for 2 hours → found out that only 1 hour is necessary as extra hour makes little difference, since the plant material only needs to be wetted here and not saturated. Also since this method is very long as well, it will save a lot of time if 1 hour is cut from the soaking time
  o 2 plastic boxes (14.5 x 14.5 x 7cm) of wet leaves
  o Cooked 2.5 hours in 3L water, 30mL washing soda (only cooked one box of leaves) → not necessary to use exhaust hood
  o 1st attempt of making paper: 1 cup leaves + 200mL water, blended 20 sec low → disastrous, fibres disintegrated, could not be lifted through mould
  o 2nd attempt: 1 cup leaves + 200mL water, blended 10 sec low → again fibres disintegrated
  o 3rd attempt: 1 cup leaves + 200mL water, blended 5 sec low → fibres long enough this time, not enough pulp, added extra cup of blended leaves to
Container → paper worked but a little too thin and weak and I accidentally broke it when it was drying
  - Not very successful → will try again with the other box of leaves tomorrow

Corn husks:
  - Cooked 1 hour (cut cooking time from 2.5 hours, which was the time I cooked leaves for when making the sugarcane leaf paper, as the leaves were too soft last time and barely needed to be blended. Cooking is like a very slow method of macerating the plant material, whereas blending is a very quick method to pulp it. It is much more efficient to cook the plants in the washing soda solution first to soften it, but only 1 hour is necessary as more time means that it is too soft and difficult to control how much it will have to blended. Cutting the cooking time is also extremely helpful, convenient and more efficient as it saves a lot of time by speeding up the process, which is especially necessary as this is such a long method, and possibly allows for more time to conduct repetitions) in 4L water, 40mL washing soda, 2 boxes of husks
  - Wasn’t rinsed enough after cooking → felt rather slimy → need to wash few more times & more carefully
  - 1st attempt: 1.5 cups + 300mL water, blended 5 sec low, pulp too chunky, blended extra 5 sec (also because this was cooked less than the sugarcane leaves) → fibres were not blended enough and paper had fibres that were too long and large, the paper was too thin and had gaps in it so there were not enough fibres
  - 2nd & 3rd attempts 2 cups + 400mL water, blended 40 sec low → paper a lot better, fibres tighter together, not flying everywhere → could still blend for longer next time to increase compactness of fibres in order to improve strength of paper

Bagasse:
  - Cooked 1 hour in 4L water, 40mL washing soda, 3 boxes of bagasse (2 boxes did not have enough fibre, as seen when making the corn husk leaf paper as there was not enough to produce 3 full sheets of paper of adequate thickness)
  - 1st attempt: 2 cups + 400mL water, blended 40 sec low → not blended enough, paper fibres too long & large, paper was thin and lacking fibre in some parts, creating some holes
  - Have had difficulty with previous attempts in creating a uniform thickness across mould → instead of pouring pulp into the container of water and then placing the mould and deckle in the water, meaning that some fibre remains underneath the mould and deckle rather than on top, it is more effective to submerge the mould and deckle in the container of water first, and then pour the pulp on top of the mould so that all of the fibre can remain in the water above the mould, allowing more of the fibre to be used to create the paper and less to be wasted, whilst also ensuring the paper does not become too thin. It is also easier to control the amount/volume of pulp used for each piece of paper this way. The plant pulp is also a lot lumpier than the pulp that was created with waste paper, so the plant fibres do not disperse as well, making it more difficult to create a uniform thickness. This means that the water and pulp in the container must be stirred thoroughly before the mould and deckle are lifted out of the water so that the fibres can be spread out across the mould as evenly as possible.
  - 2nd attempt: 3 cups + 600mL water → blended 20 sec low, 20 sec medium → better but still not blended enough to create strong paper
  - Dad suggested to remove skin of bagasse and only blend the inside fibres as the skin was too hard and not breaking into smaller thinner fibres, creating
paper with lumps of bagasse skin → this was effective as it made the pulp more consistent since the skin requires a lot of power and more time to blend to the right consistency, but the softer fibres inside can be blended to the right consistency with less power and time
  o 3rd - 5th attempts: 3 cups + 600mL water → blended 10 sec medium, 10 sec high → a lot better with thinner, more compact fibres and paper was created to how I had expected it to be

- In these trials, I experimented with different quantities of fibres, water and washing soda, blending times, and blending power to find optimal measurements that will produce highest quality paper (in regards to strength)
- Often, the pulp was not blended enough, meaning the fibres were still too long and large and could not be compacted enough in the sheets of paper, meaning they lacked some strength
- Originally, I was controlling the blending time of the different plant materials in order to ensure greater reliability of the method. However there is an issue with controlling the blending time, as the different natures of the different materials means that the pulp has to be a certain consistency for the paper to be made to an optimal level, but the different plants need to be blended for different times to achieve this → thinking of using some sort of sieve with large holes to determine whether consistencies are the same instead of controlling this variable by time taken in blending
- Also realised today that another hazard for risk assessment is slipping → due to the large amount of water being used, it is very easy to spill water onto the ground, creating a slip hazard → need to be careful when handling water and mop/wipe up any spills immediately

21/02/16

- Paper from yesterday dried → noticed that bagasse paper was quite brittle and made rips in the surface easily → decided to test tearing resistance of paper instead of stretch as these papers are very strong when I pull on them and they barely stretch. It would be too difficult to measure stretch as not only would the very minimal stretch be too small to measure accurately, it is not worth it to measure something like this with little variance and impact on these papers.
- Made sugarcane paper again:
  o Soaked some more leaves in bucket
  o Cooked 1 hour in 4L water, 40mL washing soda, 3 boxes sugarcane leaves (will cook 2.5 boxes next time instead as 3 boxes produced 5 pieces of paper, but only 3 are needed for each trial, so I should not waste the plant material I have and only use what is needed)
  o 4th attempt (adding on from yesterday): 3 cups + 600mL water → blended 30 sec medium → not blended enough, paper has small chunks of bagasse in it
  o 5th attempt: 3 cups + 600mL water → blended 40 sec medium → better but still needs to be blended a little longer, some chunks still present
  o The centre stalks of the sugarcane leaves are extremely tough and hard to blend compared to the leaf part → I decided to remove the centre stalks of the leaves from the rest of the softer leafy part so that pulp can have a more consistent texture and can be blended with more ease. This will allow fibres to be more compact in the paper and increase its strength. It is also very easy to remove these stalks when the leaves have been cooked, rather than trying to
cut them away when the leaves are dry, as the leaves are soft and easy to tear apart from the stalks after being cooked.

- 6th-8th attempt: 3 cups + 600mL water → blended 40 sec medium → no more chunks of bagasse, fibres much more even, fibres compact → a little too much fibre so paper is a little thick, 2.5 cups of leaf would be better as 3 cups is too much
- 9th attempt: 2.5 cups + 500mL water → blended 40 sec medium → paper was created as I expected it to be → good

- It seems that the optimal quantities are:
  - Cooking 2.5 boxes of plant material in 4L of water and 40mL of washing soda
  - Blending 2.5 cups of cooked plant material with 500mL of water

### 22/02/16
- Sugarcane paper finished drying
- Created table:

**Table 1: Photos of Paper Produced in Test Trials**

<table>
<thead>
<tr>
<th>Attempt No.</th>
<th>Sugarcane Leaf</th>
<th>Corn Husk</th>
<th>Bagasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Paper unable to be produced</td>
<td><img src="image" alt="Corn Husk" /></td>
<td><img src="image" alt="Bagasse" /></td>
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</tbody>
</table>

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35 •
<table>
<thead>
<tr>
<th>2</th>
<th>Paper unable to be produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
</tr>
<tr>
<td>7</td>
<td>N/A</td>
</tr>
</tbody>
</table>
24/02/16

- Emailed teacher regarding issues (teacher's comments added in red):

   Hi
   I did my trials over the weekend and I have quite a number of issues I need to sort out now.
   I realised that I can't measure the different waste materials by weight when I cook them and blend them. I had planned to cook and blend the same weights of each material to keep these variables controlled. However, sugarcane leaf is significantly lighter than bagasse, so I would have a lot of fibre for leaf but barely any for bagasse if I used the same weights. Instead I've decided to fill 3 identical plastic boxes with each of the materials after they have been soaked so that I basically have the same amount/area volume of fibre for each material going into the pot to be cooked. Also, I've decided to use 2.5 cups of each material in the blender each time after they have been cooked in order to produce each sheet of paper. Is this method of measuring the materials accurate/reliable enough to have a relatively constant amount of fibre for each sheet of paper? Yes, I think so.
Due to the different natures of the different plant fibres, this means that I am having difficulty in controlling the blending time of the different plants, e.g. bagasse generally needs to be blended for longer and on a different speed. The pulp has to be a certain consistency for the paper to be made to an optimal level. I’m not sure how I can turn this into a controlled variable. I was thinking something like seeing if the pulp can pass through some sort of sieve with larger holes to measure when the consistency is correct so that the consistency is the controlled variable rather than blending speed/time, but it doesn’t seem like using a sieve would work as it would hard to tell when to stop blending. Is there some sort of way that I can control this variable? Maybe the consistency could be gauged by pouring the mixture at a set angle and timing its flow rate? Too thin and it will flow faster. Too thick and it will flow more slowly.

I made the papers and they all turned out very strong. I was thinking of maybe adding another component to my SRP and also creating paper from normal waste paper, so that I can make a comparison of the strengths of my crop residue papers and recycled paper from waste paper. I made the recycled paper in the holidays and the crop residue papers seem stronger than it. So would it be worth it in adding this to my method to demonstrate that crop residue paper has relatively high strength and is therefore particularly suitable for papers like harder packaging paper? Yes, I like this suggestion. This would also be helpful because the handmaking method of paper produces paper with dispersed fibres rather than having a grain direction like it does when made with machines, meaning handmade paper is usually stronger, so it is not worth it comparing it to wood paper made in machines. So it would be more logical to draw comparisons to wood paper that has been created using the same method. Agreed.

Since the papers are actually quite strong, I realised it would not be worth it to test for stretch as they stretch very little and it would be extremely hard to get some measurements. Instead, I was thinking of doing a test for another property instead such as something to do with tearing resistance. I noticed that the bagasse paper created rips in the surface when I folded them and are more brittle. So I was wondering if there was a way to measure which paper was more resistant to ripping/tearing, e.g. by folding one side of the paper and applying some sort of force on the side as it is being folded to see when or with what force it rips/tears. Do you have any other sort of suggestions? I think folding, placing a controlled weight on the paper and then opening it out to see if it has split sounds good. Maybe you could measure how many times the paper can be folded in half before it splits?

Finally, on my proposal you suggested that a data logger and force probe would be better than using a spring balance to measure tensile strength/wet strength. I took a look at the force probe online and I agree that this would be much better. Although I am not too sure how to use it and does the school have one? If you fill in an order form and book into a lab session I can show you.

Kind regards
Sherie

- Talked to teacher at lunch
  - Discussed measuring consistency/viscosity of pulp → suggested that I should place teaspoon of pulp on a slope and measure time it takes to slide down to bottom, or drop a coin in pulp and measure time taken to touch bottom, as ways to ensure consistencies are the same
  - Discussed tearing resistance methods → will likely fold papers and see whether they create rips or not
  - Took a look at the force probe
- Conducted trial to find a way to measure consistency of pulp:
Blended 1 cup of leftover cooked bagasse with 200mL water for 40 sec on medium
Tried to use the slope method to test viscosity → ineffective as the fibre is easily separated from water and dependent on how much water is taken with each teaspoon, the rate the pulp slides at varies dramatically
Tried dropping coin in, but pulp is low viscosity so coin basically dropped immediately to bottom and can’t be seen through the pulp as the mixture isn’t transparent
Decided to instead, cut off the bottom of a bottle, hold the bottle upside down and pour pulp into the bottom, whilst the hand covers the mouth of the bottle, then quickly remove the hand from the mouth and start the stopwatch. When all pulp has come out of the bottle, the stopwatch is stopped, so the time taken for the pulp to pass through mouth of bottle is calculated → this is a much more effective method as it ensures that all of the blended mixture is being used to measure the consistency as it maintains and keeps controlled the ratio of fibre to water
  ▪ Used a bottle with a small mouth at first and pulp could not come out
  ▪ Changed to bottle with larger mouth → found out it was necessary to give bottle a shake sideways to mix the pulp again in order for it not to clog up mouth of bottle

Results:

Table 2: Time Taken for Bagasse Pulp to Pass through Mouth of Bottle

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.48</td>
</tr>
<tr>
<td>2</td>
<td>0.53</td>
</tr>
<tr>
<td>3</td>
<td>0.43</td>
</tr>
<tr>
<td>4</td>
<td>0.51</td>
</tr>
<tr>
<td>5</td>
<td>0.56</td>
</tr>
</tbody>
</table>

The times are relatively similar and consistent, meaning that this method is quite reliable. Only 1 cup of bagasse was used for this pulp, but in the actual trials, 2.5 cups will be used, meaning there will be a lot more pulp so less human error will be involved in taking the measurements, as this time, the pulp passed through very quickly so it was more difficult for the reflexes to respond and know when to start and stop the stopwatch.

Conducted trial of folding paper to test for tearing resistance:
  Took the two most successful pieces of each type of paper (including the wood paper) and folded each of them in half four times, noting if any rips were created:
### Table 3: Tearing Resistance of Papers

<table>
<thead>
<tr>
<th>Type of Paper</th>
<th>1st Fold</th>
<th>2nd Fold</th>
<th>3rd Fold</th>
<th>4th Fold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Sugarcane leaf</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Corn husk</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bagasse</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wood Paper</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Sugarcane leaf, corn husk, bagasse and wood paper on the fourth fold**

- The two trials indicated the same results, were bagasse paper was the only type of paper that ripped on each fold, and even ripped at all.
- For the 1st, 2nd and 3rd folds, the bagasse paper only had rips in the surface of the paper and did not tear apart, although on the 4th fold, the paper did tear apart.
- Will likely cut strips out of the paper for this test next time instead as this way, the paper can be folded a few more times to see if they will tear on the less brittle papers. This also means that I can repeat this test at least 3 times for each piece of paper itself, thus increasing reliability. As I am only producing 3 sheets of paper in each trial for each material, I wouldn’t have had enough paper to do these repetitions, which also needs to be used to conduct tensile strength and wet strength tests, so it is more efficient and increases reliability when the paper is cut into equal strips.

**27/02/16**

- Made 4 trials of bagasse paper:
  - Bagasse starting to get a bit mouldy → will need to get new bagasse for next time
  - Blended 60 sec medium
Consistency of pulp should be 0.6-0.8 seconds to finish coming out of bottle

28/02/16
- Made 3 trials of sugarcane leaf paper
- Made 3 trials of corn husk paper

04/03/16
- Considered whether it is necessary to measure thickness of pieces of paper using micrometer as they all differ since they are not uniform sheets of paper
- Teacher suggested maybe to place a few sheets of paper together and measure random thicknesses to show that all of them are not uniform and not just a few of them are like this

05/03/16
- Made 2 trials of corn husk paper
- Made 4 sheets of recycled wood paper

06/03/16
- Made 4 trials of sugarcane leaf paper

08/03/16
- Had a go with the micrometer on some sugarcane leaf paper→ thicknesses of paper did vary
- Very difficult to control

12/03/16
- Made 2 trials of corn husk paper
- Made 2 trials of bagasse paper

13/03/16
- Made 1 trial of corn husk paper
- Made 2 trials of bagasse paper
- All crop residue paper finished being made
- Revised method to test for tensile strength and wet strength:
  - Cut strips of paper → Dad held onto one end and I held onto one end and pulled → paper could be broken without too much force → paper can probably be taped down to bulldog clip and ripped rather than just slipping out of tape
Used sticky tape to stick strips of paper on bulldog clip and used thumb to hold down other end of paper on corner of table → sugarcane leaf paper and tree paper was too strong and were pulled out of the tape before they ripped
Went to Bunnings to buy gaffer tape
Gaffer tape was able to hold down all paper

15/03/16
- Made rest of tree paper
- Cut out strips of paper
- Created tables for results for tomorrow’s testing
- Created codes to label each sheet of paper
  - B = bagasse
  - C = corn husk
  - S = sugarcane leaf
  - W = recycled waste wood paper
  - 1, 2, 3 etc. = repetition no. of the paper
  - X = 1st sheet of paper of that repetition
  - Y = 2nd sheet of paper of that repetition
  - Z = 3rd sheet of paper of that repetition

16/03/16
- Conducted tensile strength test for all bagasse, corn husk, sugarcane leaf and most waste paper
- Conducted wet strength test for all sugarcane leaf paper

17/03/16
- Conducted tensile strength test for rest of waste paper
- Conducted wet strength test for all bagasse and waste paper

18/03/16
- Conducted wet strength test for all corn husk paper
- All tensile and wet strength tests complete
- Results:

<table>
<thead>
<tr>
<th>Paper</th>
<th>Tensile Strength (N)</th>
<th>Wet Strength (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>B1X</td>
<td>-6.2</td>
<td>-3.2</td>
</tr>
<tr>
<td>B1Y</td>
<td>-10.2</td>
<td>-10.1</td>
</tr>
<tr>
<td></td>
<td>B1X</td>
<td>B1Y</td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>C2Z</td>
<td>-36.1</td>
<td>-44.4</td>
</tr>
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<td>C3X</td>
<td>-42.9</td>
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<td>C3Y</td>
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<tr>
<td>C3Z</td>
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<tr>
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<td>C5Z</td>
<td>-35.2</td>
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</tr>
<tr>
<td>C6X</td>
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</tr>
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<tr>
<td>C7Z</td>
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<td>C8X</td>
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</tr>
<tr>
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</tr>
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<td>-27.9</td>
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<tr>
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<td>-24.2</td>
</tr>
<tr>
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<td>-33.7</td>
<td>-23.3</td>
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<td>-19.8</td>
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<td>S4X</td>
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<td></td>
<td>-34.3</td>
<td>-30.3</td>
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19/03/16

- Began writing up report
- Conducted folding endurance tests:

<table>
<thead>
<tr>
<th>Paper</th>
<th>Ability to Withstand Tearing when Folded in Half</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fold 1</td>
</tr>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>B1X</td>
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</tr>
<tr>
<td>B1Y</td>
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<tr>
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<td>---</td>
</tr>
<tr>
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</tr>
<tr>
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20/03/16

- Completed aim, hypothesis, risk assessment, equipment, method and conclusion sections
- Created all tables of results

21/03/16

- Asked teacher about whether tensile strength and wet strength should still be called ‘tensile strength’ and ‘wet strength’ as they are not measured or expressed in conventional terms in this SRP as they are not measured in N/mm → not an issue
- Completed SRP :)

22/03/16

- Printed and bound SRP
- SRP handed in :)

26/05/16

- Marked SRP handed back

13/08/16

- Started to edit SRP according to marker’s comments
- Made edits to tables and graphs and discussion
14/08/16

- Continued to edit discussion

17/08/16

- Talked to teacher about SRP
- Suggested that I should calculate standard error and insert error bars into graphs
- Discussed ways to improve validity section of discussion

18/08/16

- Calculated the standard error and inserted error bars based on those figures
- Worked on discussion

24/08/16

- Discussed issue of standard error and error bars with teacher
  - The standard error calculations indicated a very small margin of error, so the error bars also appeared to be very small, suggesting that there was little variability within the raw data. The calculated standard error was small as there were 72 repetitions, which were a lot. The standard error figures were misleading, as the results were actually very spread apart, as indicated by the high standard deviations.
  - The standard error values were removed and the error bars were changed to show standard deviation instead
- Changed 1dp to sig. fig. in tables
- Began to rewrite discussion

25/08/16

- Finished discussion
- Edited reference list
- Changed Graph 3 to show percentage rather than number
- Edited final report
- Submitted report to STANSW

05/10/16

- Edited part of report for BHP Billiton Science and Engineering Awards