As strong as your weakest rope....

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Grade 6
Forth Primary School

Topic:

Rope formations and force.

Abstract:

When beginning my investigation, I started off with a few ideas, but was interested in the area of materials. I wanted to begin testing the strength of a certain material, possibly fabric, but eventually changed to rope. I created my scientific question; which rope formation can withstand the most force?
I decided to test the following formations: original/nothing, knots, braid, plait, twist, and finger knitted. I hypothesised that if a material is formed into different formations, then this will effect the strength of the material to withstand force. If a material is formed into a plait formation, then it will withstand more force than other formations, up to 8 Newtons more. When the test samples for each formation were ready, I began testing. The results of my investigation showed that the original rope formation was the strongest, able to withstand the most force, reaching an average of 13.2 kg of force. This was followed by knots, and twist (12.8 kg and 11.7 kg). Finger knitting (11.7 kg), plait and braid (8.7 kg and 8.2 kg) rounded out my results. Once my testing was complete, I examined my results. My findings suggested that knots may be the strongest formation able to withstand the most force, as original rope was at first intended as a reference. These findings proved my hypothesis incorrect, as I believed plait would be the strongest formation. From this, I recommend the use of a non-adjusted (original) rope formation, as it withstood 0.4 more kg of force more than the second strongest rope formation. This information could help people through sports like rock climbing and sailing, and increase safety levels for those participating.

Background Research:

- **What are possible methods to test the strength of a material?**
  Leonardo Da Vinci created an experiment, testing the strength of iron wires. The experiment was constructed with a basket attached to the end of a steel wire, where a hopper was continuously feeding sand until the weight of sand caused the wire to snap. The sand was being used as a form of measurement. This experiment was called " Testing the strength of iron wires of various lengths." Another instrument of measurement was created by Sir Isaac Newton, who created the Newton Meter named after himself. While the exact date is not known, this unit of measurement was created about 21 years ago, after Isaac Newtons death (being the founder).mThe invention measures the force of an object's strength in Newtons, or kilograms.

- **What are different types of material?**
  There are two types of materials, hard materials and soft materials. Soft materials are materials easy to "compress", while hard materials are the opposite. Metal, being a natural and hard material is one of the three "trading materials". Polymer, a soft material, is a man-made and natural chemical, used in materials such as cloth. And ceramic, which is a piece of hard material, possibly made of clay, earth materials, water and powders – a form of china/clay.

- **What are formations for materials?**
  Fabric is formed by weaving, knitting, crocheting, knotting, tatting, felting or braiding. Other ways to seal off a rope may be holding a match to the ends, tying a knot and reweaving the rope back in on itself. These all also explain how a rope might fray and therefore lose its formation.

Scientific Question:

Which rope formation can withstand the most force?

Hypothesis:

If a material is formed into different formations, then this will effect the strength of the material to withstand force. If a material is formed into a plait formation, then it will withstand more force than other formations, up to 8 Newtons more.

Variables:

Independent variables

- Cotton rope formations
- original/nothing
- knots
- braid
- plait
- twist
- finger knitted

Dependent variables

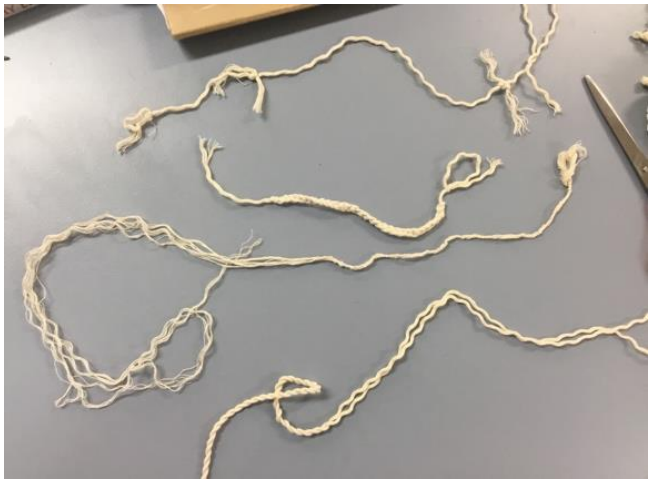
- Newtons / strength (grams – kilograms)

Controlled variables

- cotton rope
- length of rope
- testing method
- measurement unit
- measurement device
- location of testing
- air temperature of testing area

Materials:

- Newton force meter
- 6x 80cm lengths of cotton rope
- attachable, non-moving surface
- formation instructions
- person to pull meter
- measurement tape
- scissors
- recording table
- tape
- iPad for photos
- pencil



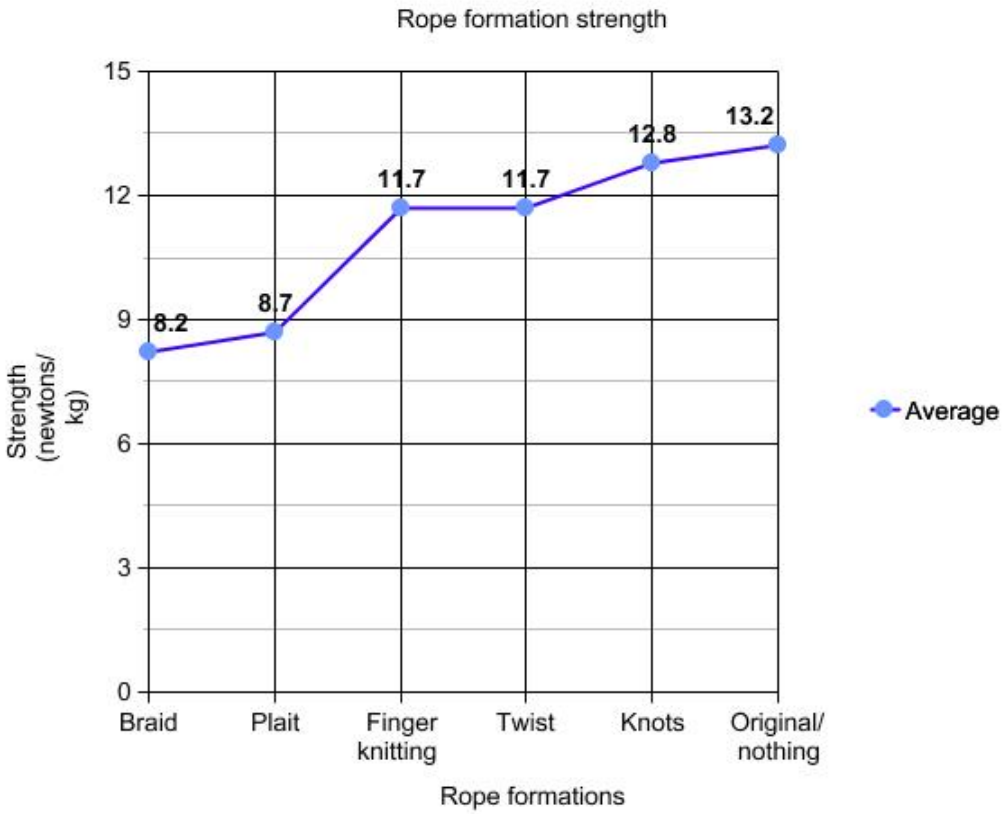
Method

- Step1: Split 80 cm piece of cotton rope into 1/3
- Step 2: Use 80 cm piece of cotton rope and select a formation from list below:
  Do either a
  - original/nothing
  - knots
  - braids
  - plaits
  - twist
  - finger knitted

- Step 3: Once complete, attach cotton rope in a simple knot to a solid, non-moving object, and attach free end to newton force meter.
- Step 4: Pull on newton force meter slowly, one hand holding the handle and another holding the measurement area, until cotton rope snaps.
- Step 5: Record amount of newtons reached, into table.
- Step 6: Repeat process another two times, using the same formation with another piece of cotton rope. Then calculate an average in total for formation.
- Step 7: Repeat whole process, using each different formation, with a new piece of cotton rope for each test.

Results:

Listed Formations Tested	1.	2.	3.	Average Newtons
• original/nothing	13 kg/ 29 lbs	13 kg/ 29 lbs	13.5kg/ 30 lbs	13.2kg/ 29.3 lbs
• finger knitted	11.5 kg/ 25 lbs	11.5kg/ 25 lbs	12 kg / 27 lbs	11.7 kg / 25.7 lbs
• braids	8 kg / 18 lbs	8.5 kg / 19 lbs	8 kg / 18 lbs	8.2 kg / 18.3 lbs
• plaits	9 kg / 20 lbs	8.5 kg / 18 lbs	8.5 / 18 lbs	8.7 kg / 18.7 lbs
• twist	12 kg / 26 lbs	10 kg / 22 lbs	13 kg / 29 lbs	11.7 kg / 25.7 lbs
• knots	13.5 kg/ 30 lbs	12.5 kg / 27 lbs	12.5 kg / 27 lbs	12.8 kg / 28 lbs



Analysis/Discussion:

The results of my investigation showed that the original rope formation (untouched) withstood the most force according to the newton meter. Knots were second, withstanding a force of 12.8 kg, twist was third, tied with finger knitting, then plait, with the weakest being braid withstanding an average force of 8.2 kg. The original rope formation withstood 0.4 more kg of force more than the second strongest rope formation.

I was not expecting such a variation throughout the formation results, and was surprised to find that there was a 5.0 kg difference between the highest withstanding rope formation and the lowest withstanding rope formation.

With the original, twist and knots being the three top formations to withstand the most force throughout the test (13.2 kg, 12.8 kg and 11.7kg respectively), I noticed most of the time (unlike the weaker formations) these ropes specifically snapped either in front of the knots attaching the end of the ropes to the meter or rail, or in the loops. When testing braids and plaits (the two weakest formations), I was surprised to find they snapped around the half way mark in the middle. I think after looking at the results, the more parts each rope was divided into, the weaker in strength and the less force it could withstand.

I hypothesised that if a material is formed into different formations, then this will effect the strength of the material to withstand force. If a material is formed into a plait formation, then it will withstand more force than other formations, up to 8 Newtons more. I found my hypothesis was refuted, as plait was found to be the second weakest out of the rope formations, and no formation differed from eight Newtons in comparison. But, changing the formation of a rope did have an impact on the rope's ability to withstand force (although not in the predicted way). Original rope formation withstood the most force, however if this was not included as a formation as it was first intended as a reference, then knots would place to be the strongest rope formation, able to withstand the most force.

During my investigation, I did face some minor challenges; one of which would be time management. I did not complete my testing as early as possible due to refining details of my investigation. If I had tested earlier, it would have given me more time to prepare for completing and analysing results. Another challenge was coming up with a design for my board and cover page, as I found it difficult to make a decision and found this too time consuming. I enjoyed

working by myself and not having to rely on people, although sometimes working with others may have helped with time, decorations and ideas.

If I was to repeat my investigation and make improvements, next time I would focus on getting to my testing earlier to get my results. This would allow me to start thinking things over and preparing for areas such as my analysis, discussion and real world implications. I would also test the formation of a different material such as a living thing (maybe plant), and look at different ways to test.

Real World Implications:

I believe my investigation could have real world implications, including in sport. Rock climbing and sailing both require ropes in their sport. If a rope is weakened by the formation it is in, it will put the person and equipment at risk. With people being aware of the formation which can take the most force, these can become safer sports and environments for participants. This information could be applied to the designs and systems to ensure the user is in as safe a state as possible. Another way this knowledge might be used is to contain materials, change set-up formations and systems, and support transport cargo, pulleys and systems. I think while most ropes are strong and can take the force required in these sports and uses, this new piece of information could improve these systems in our ever-changing world.

Conclusion:

I investigated which rope formation can withstand the most force. I hypothesised that if a material is formed into different formations, then this will effect the strength of the material to withstand force. If a material is formed into a plait formation, then it will withstand more force than other formations, up to 8 Newtons more. I found my hypothesis was refuted, as plait was found to be the second weakest out of the rope formations, and no formation differed from eight Newtons in comparison. But, changing the formation of a rope did have an impact on the rope's ability to withstand force (although not in the predicted way). Original rope formation withstood the most force. I recommend the use of a non-adjusted (original) rope formation, as this withstood 0.4 more kg of force more than the second strongest rope formation. I think while most ropes in sports and constructions are strong and can take the force required, this new piece of information could improve these systems and their safety in our ever-changing world.

Acknowledgements:

- Mr Vannini (student) – Provided Newton meter.
- Miss Konkes (student) – Assistance with photos.
- Mr French (teacher) – Assistance/direction in project, provision of materials and review over report.
- Forth Primary School (school) – Supply of equipment

References:

- Mithil Kamble. (2018). Is a long rope weaker than a short one? https://www.quora.com/Is-a-long-rope-weaker-than-a-short-one

- eSchoolToday. (2020). What is a Force and how is Force measured? https://eschooltoday.com/science/forces/what-is-a-force.html

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College of Sciences & Engineering

SCIENCE AND ENGINEERING INVESTIGATION AWARDS

RISK ASSESSMENT

This form is required for all Science and Engineering Investigation Awards projects. **This form should be completed before you start your investigation or design project.**

Student's Name/s:	Isabella Kären Beatrice Connelly
Year Level:	Grade 6
Teacher/Mentor:	Daniel French
Title of Project:	~~Only~~ as strong as your weakest rope....

You will need to answer Questions 1 and 4 for all projects. You will only need to answer Questions 2 and 3 if you are using hazardous materials, equipment or potentially hazardous biological agents.

You must include a copy of this form with your investigation or design project report.

1. **Investigation/Design project risks**

a. List the risks involved in your project.

- Hand jamming
- Scissor cuts
- Cutting of circulation
- Cuts in general

b. Describe the safety precautions and procedures that you will use to reduce these risks.

- Proper use of device
- Proper use of scissors
- No use around necks and only tied in listed formation
  - No wrapping around body parts (not including hands)
- Keeping hands in safety position

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2. **Specific hazards (if applicable)**

a. List all hazardous chemicals, activities, and/or equipment that you will use.

b. List any potentially hazardous biological agents that you will use.

c. Describe the safety precautions and procedures that you will use to reduce the risks associated with hazardous chemicals, activities, equipment, and/or any potentially hazardous biological agents as listed above.

3. **Disposable of hazardous materials (if applicable)**

Describe the disposal procedures of any hazardous chemicals or potentially hazardous biological agents that you will use.

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4. References

List the source(s) of safety information you used, including websites, books or laboratory safety guidelines.

- Scissors –
University of California Agriculture and Natural Resources. (2018). 39 safe scissor use. safety.ucanr.edu/files/3130.pdf

- Hand jamming –
Dana Sparks. (2017). Home remedies: just jammed your finger? newsnetwork.mayoclinic.org

- Cutting of circulation –
Webmd. (2020). 12 tips to improve your circulation. webmd.com

- Cuts –
American Academy of Dermatology. (2020). How to treat minor cuts. aad.org

☑ I/We have talked with my/our teacher/mentor about the **risks** associated with this project and how I/we will manage these.

☑ I/We have discussed with my/our teacher/mentor about any **specific hazards** associated with this project and how I/we will manage these, including the safe disposable of any hazardous materials.

Signed: Date 20th August 2020

Isabella Connelly (student)

Daniel French (Teacher)