Looping Hyperbolic Surfaces

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Abstract

This workshop aims to explore how the material contexts and the bodily knowledge involved in weaving can contribute to our understandings of space and geometry. A key aim is to investigate relations between mathematical notions of hyperbolic surfaces and a looping technique that can be used to generate them. During the session we will get familiar with circular looping, and create our own hyperbolic surfaces whilst discussing their connections to mathematics and curvature.

Introduction

This workshop originated from a project called "Forces in Translation - Basketry: Mathematics: Anthropology" [5]. The project is a collaboration between basket weavers, mathematicians/mathematics educators and anthropologists who, together, investigate different possible synergies between basketry, mathematics and anthropology. Since the beginning of the project in 2019, several online and in-person studios have been held and have given rise to various transdisciplinary explorations. Among other things, these studios highlighted different themes through which different bodily skills and experiences involved in basket weaving can contribute to our understanding of geometry. This workshop, which will be focused on the notion of hyperbolic surfaces through circular looping, is one of the fruits of such exchanges.

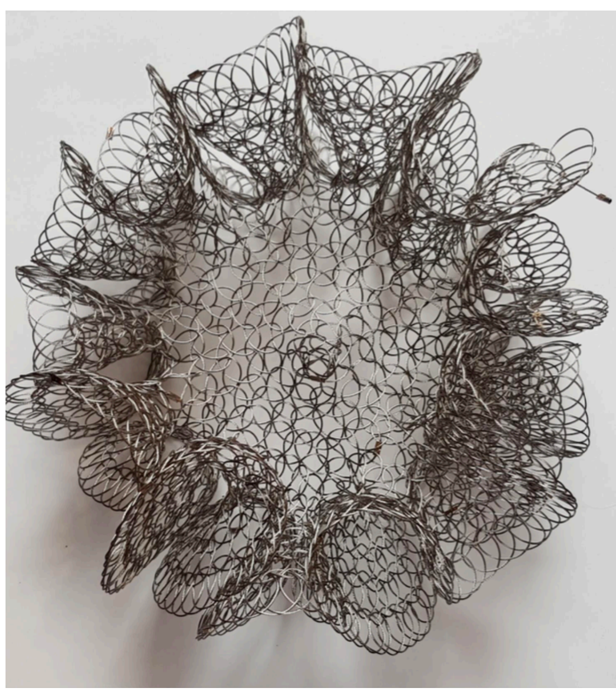


Figure 1: *Stainless-steel metal wire piece by Geraldine Jones*

Cycloid weaving or circular looping techniques, which are commonly practiced in Borneo and the Far East, are part of skills attached to the making of baskets and basket parts used in the context of rice cultivation, hunting and domestic work [3]. Traditionally made of rattan or bamboo, these techniques stand out for their strong geometrical patterning and for the malleable structures they can form when made of soft and flexible material [2]. In our investigations with circular looping, we have noticed the emergence of surfaces with particular negative curvature arising when particular increases in the number of loops between each layer of weaving have to be accommodated within a single surface. The surfaces created can be understood as approximations of hyperbolic surfaces. In contrast with spheres which have a constant positive Gaussian curvature, hyperbolic surfaces are of constant negative Gaussian curvature [1]. Figure 1 shows a stainless-steel metal wire piece made by Geraldine Jones in which an increase related to the Fibonacci sequence in the number of loops from ring to ring leads to a growth of such an approximation of a hyperbolic surface.

In exploring relations between crafting techniques and curved surfaces we are continuing a 20-year-old line of research. Daina Taimina [4] and Margaret Wertheim [5] both highlighted crochet as an important technique for creating hyperbolic surfaces. Expanding the work of these authors, in this workshop we propose to investigate the notion of hyperbolic surface with the circular looping technique by creating negatively curved surfaces with cane. For those who are not experienced crochet stitchers, circular looping is likely to be more accessible and reveal more clearly the growth structure of the surface.

The Plan

This 90-minute workshop will include three periods:

Period one—Introduction and getting familiar with circular looping (25 minutes)

Introduction to our interests in math/art/craft (5 minutes). Getting to know hyperbolic surfaces through discussion with participants (10 minutes). Getting familiar with circular looping by creating a first row of 8 loops around a centre hoop (10 minutes, participants will work in teams, number of participants in each team will depend on availability of material).

Period two—Hyperbolic Looping (45 minutes)

Creating a hyperbolic surface by adding series of loops to the structure: a second row of 16 loops, a third row of 32 loops, a fourth row of 64 loops, doubling the number of loops each time.

Period three—Discussion (20 minutes)

Sharing creations and discussion with participants.

Material and Instructions for Each Period

Material required for each team

30m of 2mm cane (to make 4 rows); masking tape; scissors; marker.

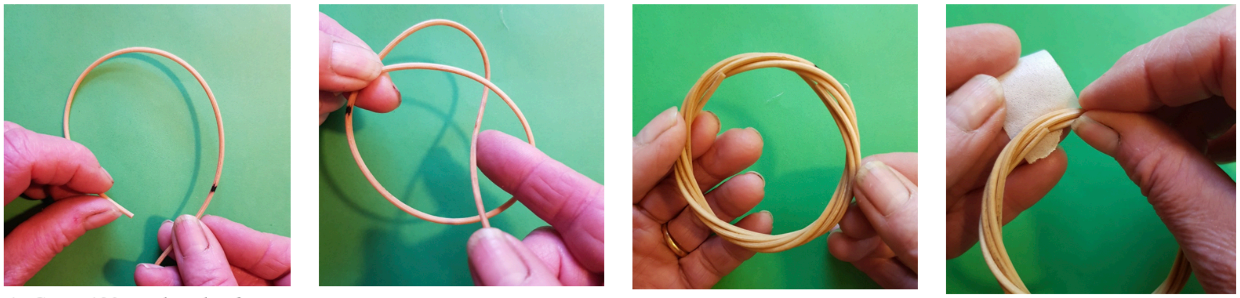
We chose to work with cane for the scale at which this material allows to work. However, it is interesting to observe the variations produced by different materials in relation to the forces and tensions they generate.

Period 1—Introduction and getting familiar with circular looping

This section includes detailed instructions for making the centre hoop (Figure 2), looping the first 7 loops around the centre hoop (Figure 3) and linking the eight loop (Figure 4).

Period 2—Hyperbolic Looping

Following the formation of the 8 loops around a centre, we will increase the number of loops to form a hyperbolic surface (Figure 5). This section includes detailed instructions for creating the subsequent rows of loops: Making the first loop of a new row—a FULL loop (Figure 6); Making the second loop of a new row— an INCREASE loop (Figure 7); Completing the new row (Figure 8). Each new row of loops will contain twice as many loops as the previous row. The second row will then contain 16 loops (8x2), the third 32 (16x2), the fourth 64 (32x2) and so on…



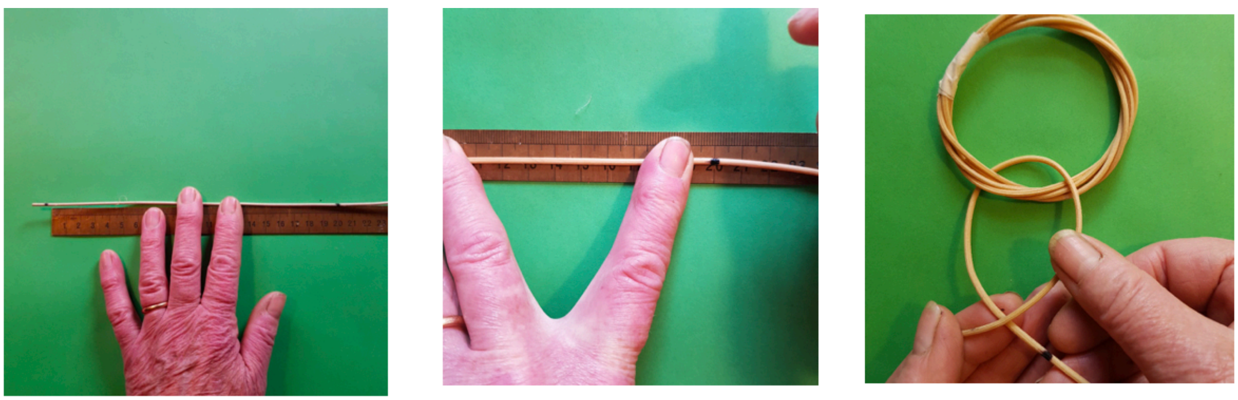
1. Cut a 120 cm length of cane and mark at 20 cm to delineate the circumference of the hoop.

2. Wrap it around itself several times to make a firm centre.

3. Until you have no cane left

4. Secure with masking tape.

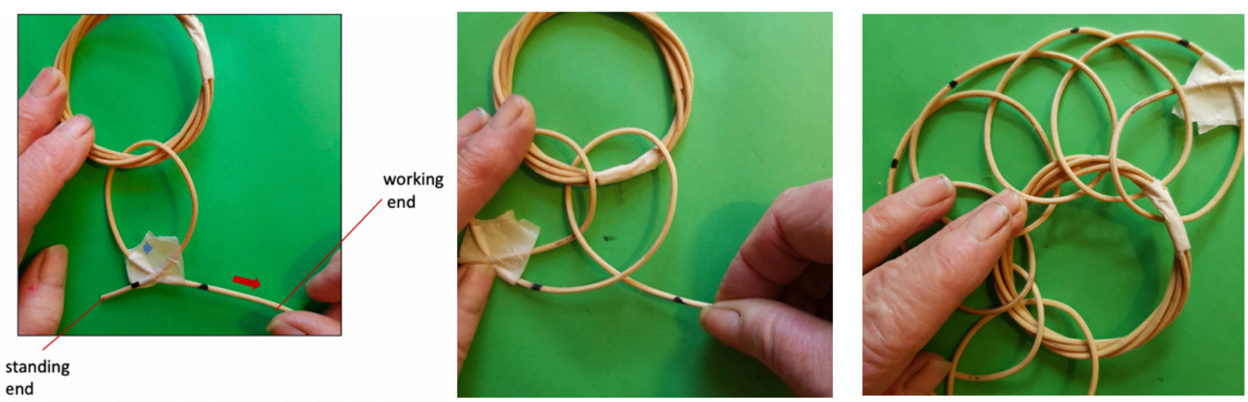
Figure 2: *Making the centre hoop*



1. Cut a 162 cm length of cane and mark 1 cm from the end

2. Continue to mark 20 cm intervals to the other end with approx. 1 cm spare

3. Make the first loop going through the centre hoop



4. Secure the first crossing with masking tape

5. Join the second loop.

6. And so on, until you have 7 loops

Figure 3: *Looping the first 7 loops around the centre hoop*

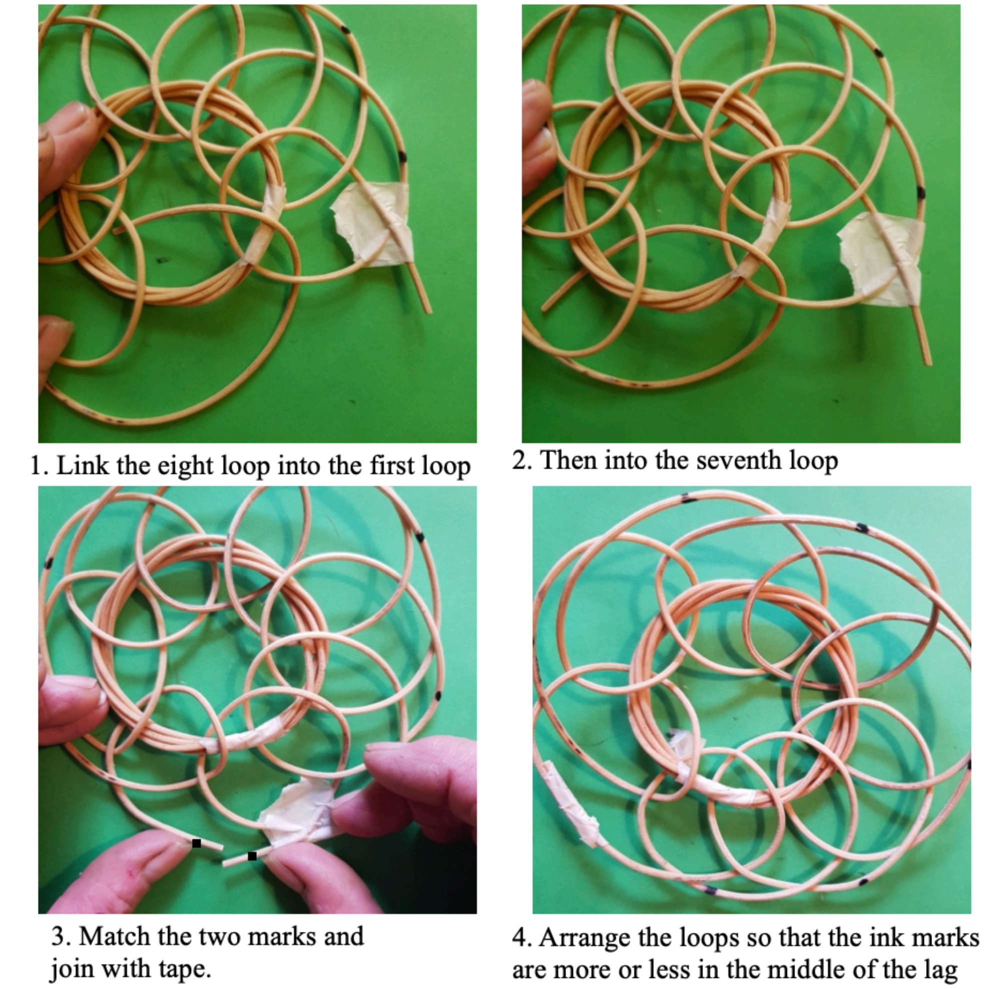


Figure 4: *Linking the eight loop*

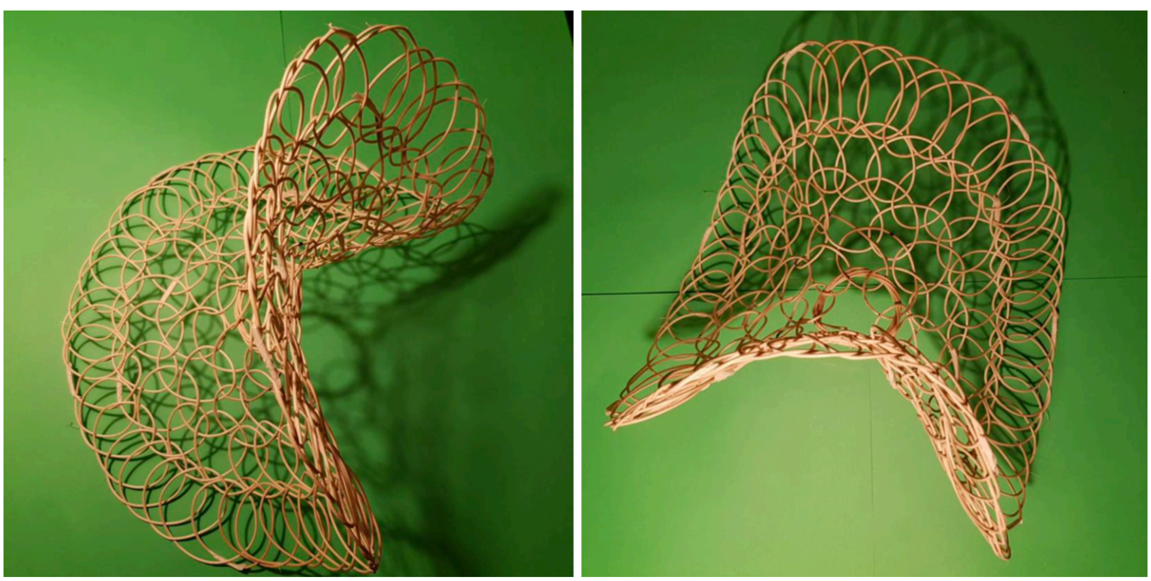
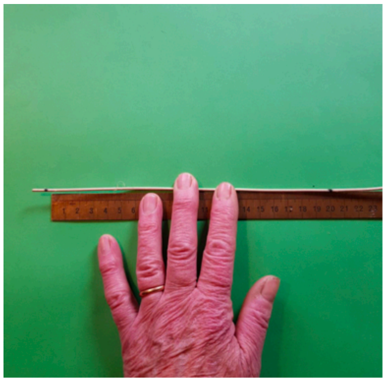
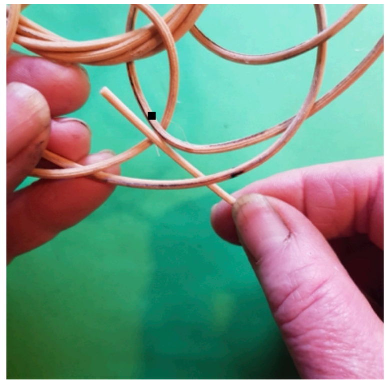


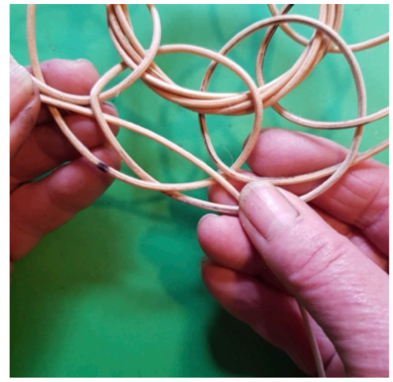
Figure 5: *Hyperbolic looping with 4 rows*



1. Cut a 162 cm length and mark 1 cm and continue marking 20cm to the other end.

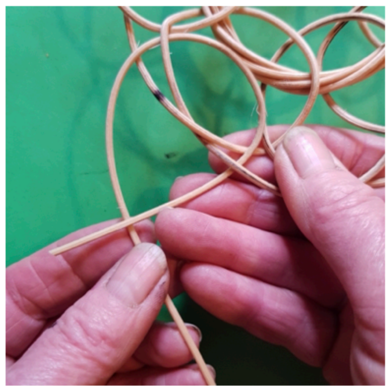


2. Thread behind and up into the lag and over the loop above

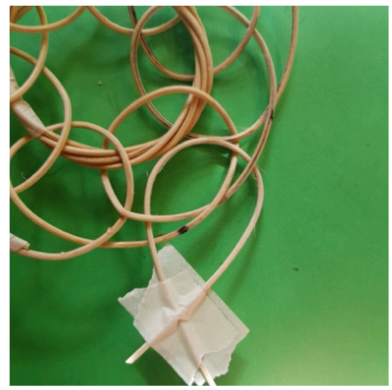


3. Then under and out of the loop and into the previous lag

4. Pull the entire length of cane

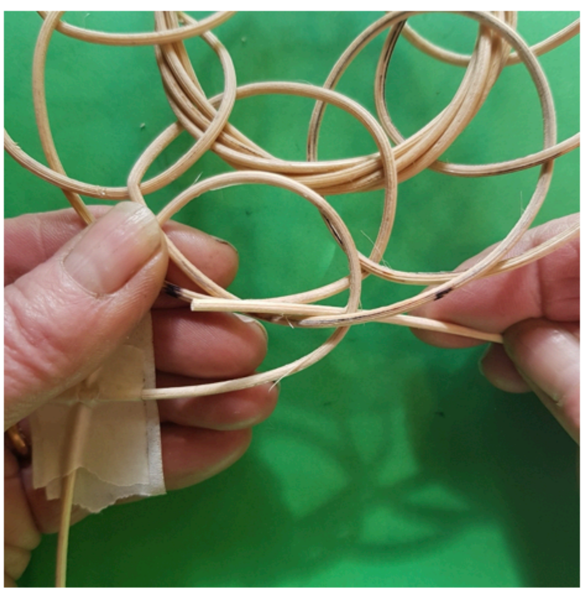


5. You have a FULL loop

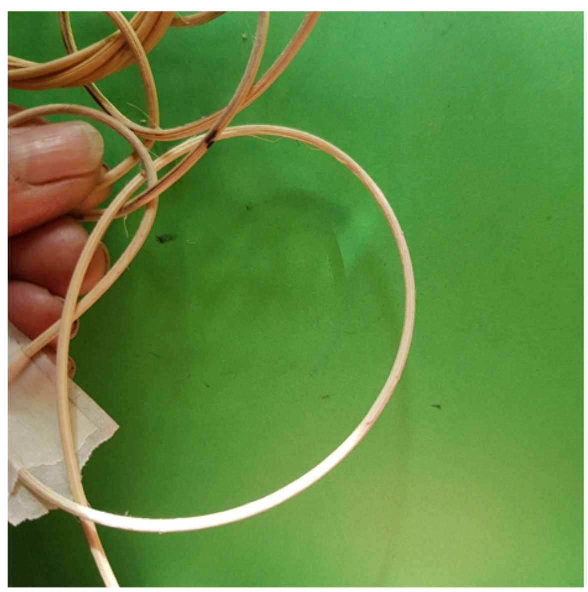


6. Secure with tape

Figure 6: *Making the first loop of a new row (FULL loop)*

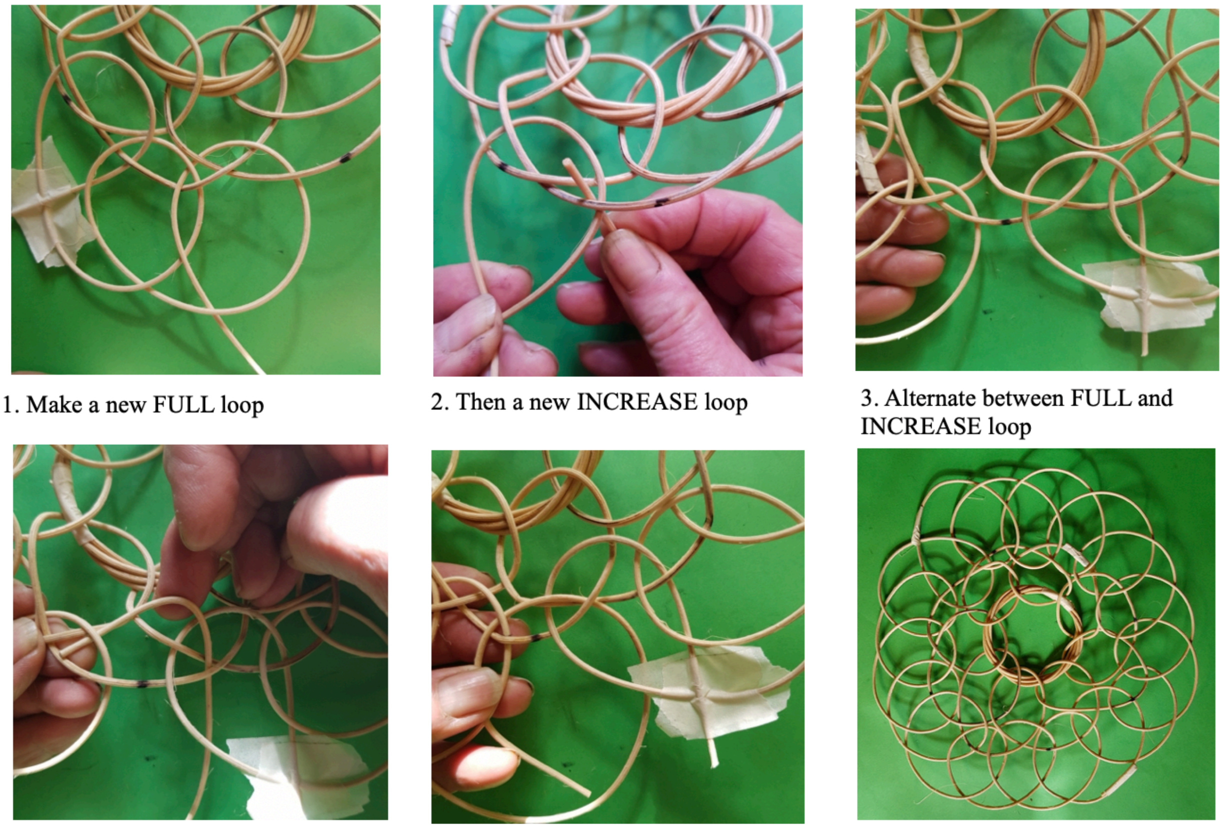


1. Thread through the lag this time NOT linking to a full loop above



2. Pull over the lag, over the first loop then under itself to complete the second loop

Figure 7: *Making the second loop of a new row (INCREASE loop)*



1. Make a new FULL loop
2. Then a new INCREASE loop
3. Alternate between FULL and INCREASE loop
4. The last loop goes through like this
5. Joins the first
6. And connect with tape

Figure 8: *Completing the new row*

During our explorations with cane, we noticed that the structure started to curve at the 4th (64 loops) or 5th (128 loops) row (Figure 8). The additions of rows of 8 loops, 16 loops and 32 loops seem to keep the structure fairly flat, whereas the tensions created by the addition of the 64 loops in the 4th row and the 128 loops in the 5th row generate curvatures. Several questions remain regarding this observation, the possible variations and their possible relations with the type of curvature created: what impact does the size of the centre hoop have? The material used? The size of the loops? The growth rate (e.g. doubling each row)? What part of the human body has a similar surface curvature? How would you measure the curvature of this surface? These questions are some of the prompts for the final discussion period.

References

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[6] https://forcesintranslation.org