NORTHERN ARIZONA UNIVERSITY

O.S. ORIGAMI SPYGLASS

Origami Spyglass for Economic and Educational Advancement in Lesoit, Tanzania

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Outline

- Design Challenge
- Community Background
- Product Designs Process
- Cost and Risk Analysis
- Future Milestones
- Acknowledgements
- References

Clients and Stakeholders

Figure 1: Maasai Woman and young girl [1]

Figure 2: School Children [2]

Figure 3: NAU Engineering Building in Flagstaff, AZ [3]

Product Considerations

- Design affordable academic tools to reduce dropout rates and promote STEM education in rural schools.

- Design a business model that improves the income of the community while tailoring local jobs to the cultural life of Maasai women.

Local Economics

- **Tourism**
  - Revenue increase of approx. 27.5 million US dollars over 5 years [4]
  - Visitors increase of approx. 122% over 5 years [5]

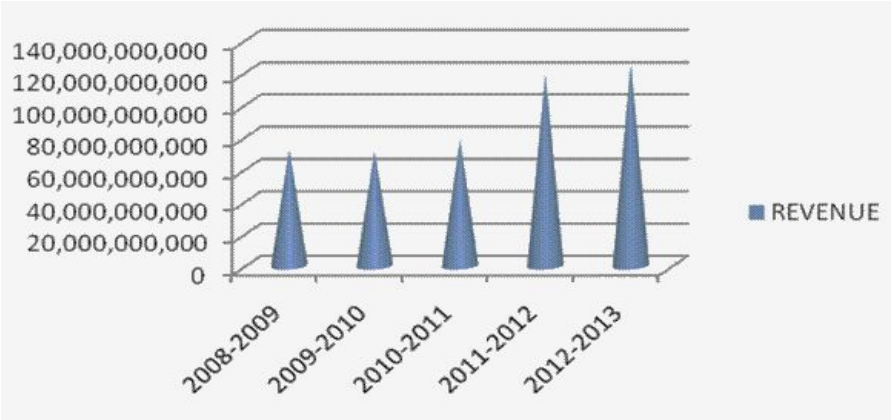


Figure 4: Yearly Tourism Revenue in Tanzania (2008-2012) [4]

Table 1: Tanzania Visitor Population Increase (2008 - 2012) [5]

S/N	YEAR	TOTAL NUMBER OF VISTORS
1	2008-2009	736,829
2	2009-2010	679,006
3	2010-2011	682,218
4	2011-2012	942,664
5	2012-2013	901,892

Current Education

- Drop-out rates [6][7]
- Current Science Lab Programs
  - Biology
  - Chemistry
  - Physics
- Mentorship and job shadowing[8]

Figure 5: Travel for education [9]

Product Description

- Origami Spyglass
  - Based on Foldscope
- Wildlife Educational Booklet
  - Coupled with Classroom Lesson Plan
- Tourism Booklet

BILL OF MATERIALS	(CENTS)
1. Printed polymer Micro-optics	10
2. Paper Apertures	5
3. Polymer dye filters	5
4. Printed condenser lens	5
5. Printed LED	15
6. Paper Micro-flexures	5
7. Watch Battery	5
Foldscope	50

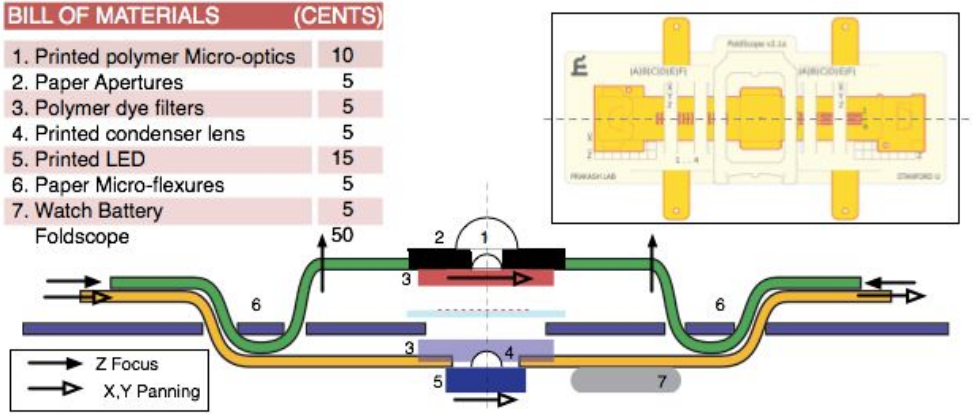


Figure 6: Foldscope Cross-Sectional Diagram of Design + Bill of Materials [10]

Product Description: Spyglass Design Criteria

- **The spyglass must be designed to:**
  - Be constructed from single sheet of paper
  - Minimize or eliminate the use of adhesives
  - Maximize the rigidity of the housing
  - Provide simple assembly for young students
  - Maximize product lifetime (Durability)

Figure 7: basic spyglass [11]

Lens Design: Theory

- Galilean telescope
  - Simple construction
  - Two lenses (concave and convex)

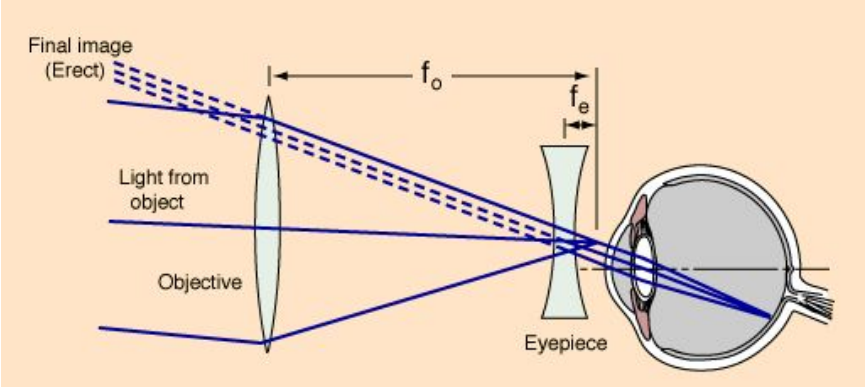


Figure 8: Galilean telescope [12]

Table 2: Important Design Values

Lens Properties	Current values
Material Refractive Index (n)	1.514 [15]
Length of Spyglass (L)	15 cm (chosen)
Magnification (M)	10x (chosen)
Objective Lens Focal Length (Fo)	16.67 cm
Eyepiece Lens Focal Length (Fe)	-1.67 cm

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$L = f_o + f_e$$

$$M = -\frac{f_o}{fe} \qquad [13,14]$$

Lens Design: Manufacturing

Photopolymer 3D Printing

- FormLabs Form 1+ Printer
  - Prints using lasers instead of a filament
  - Allows for the printing of clear, acrylic resins
- Lens Printing Demonstration
  - Printing method allows for usable final product with minimal post processing

Figure 9: FormLabs Form 1+ 3D Printer [16]

Figure 10: Lens Printing Demonstration of the Form 1+ 3D Printer [16]

Housing Design

- Four initial design ideas:
  - Cylindrical, accordion, square cross-section, and ‘Tri-Hex’ cross-section
- Digital models created for each concept
- Concepts chosen for assembly prototyping:

Figure 11: Square Cross-Section 3D Model

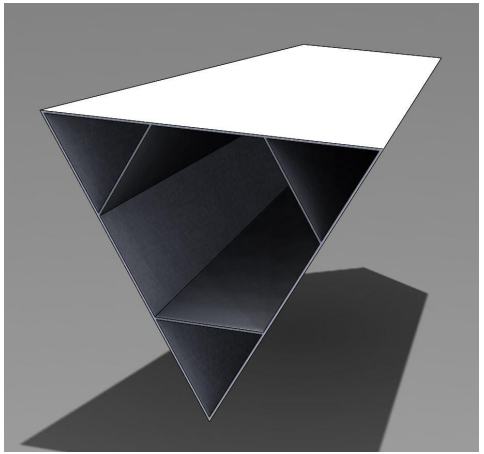


Figure 12: Tri-Hex Cross-Section 3D Model

Housing Design: Assembly Prototyping

- Housing Assemblies:

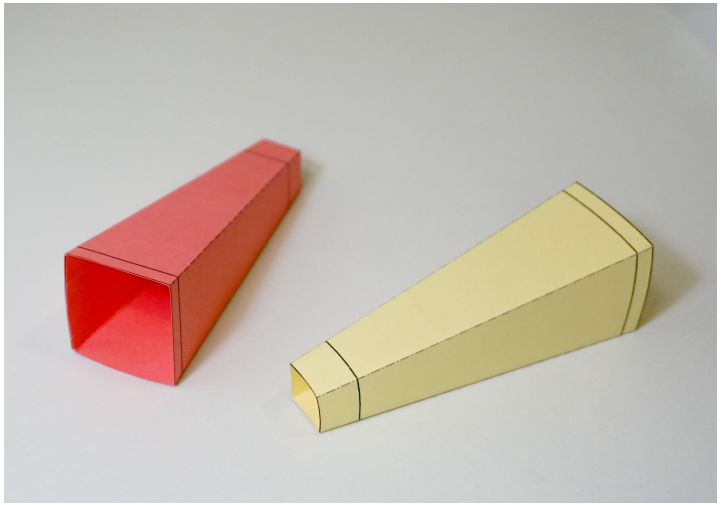


Figure 13: Square Cross-Section Prototype

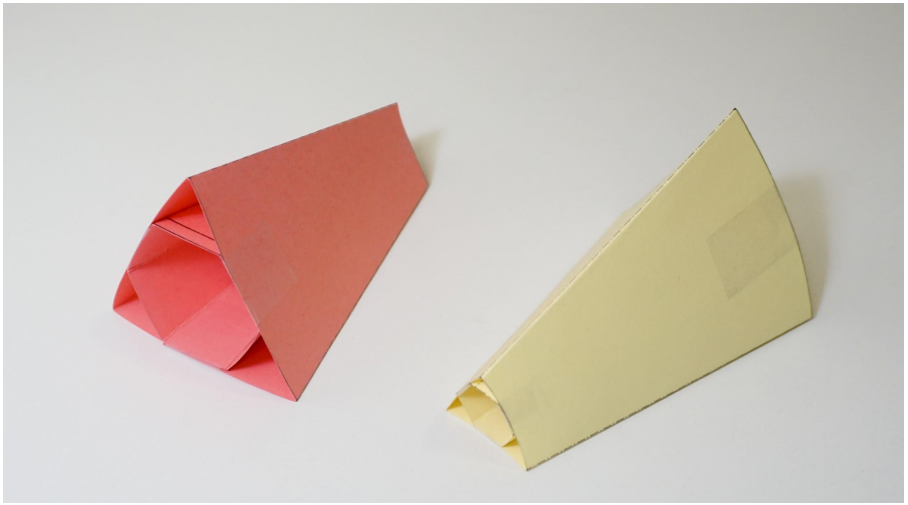


Figure 14: Tri-Hex Cross-Section Prototype

Housing Design: Assembly Prototyping

- Fastening Methods:

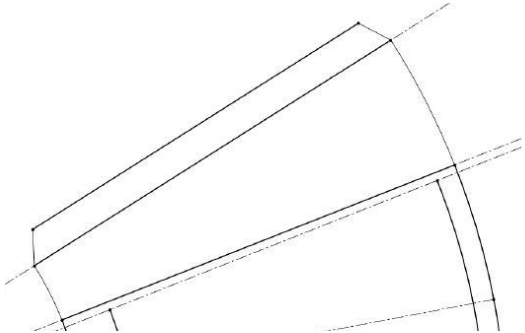


Figure 15: Single Tab Method

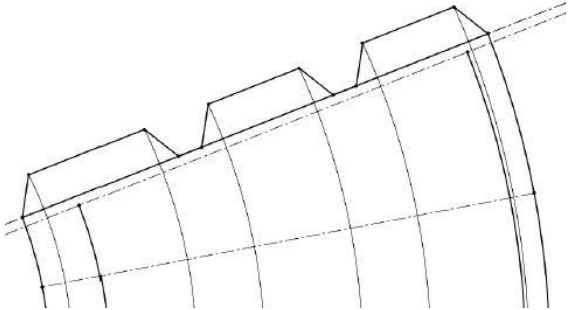


Figure 16: Multi-Tab Method

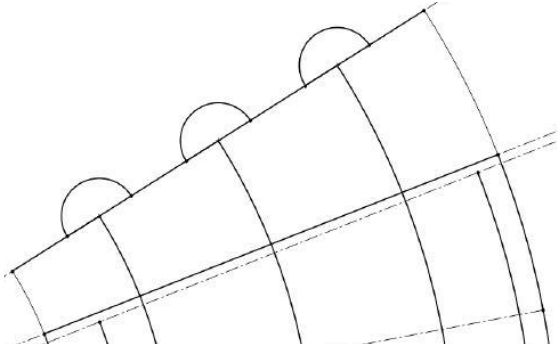


Figure 17: Hook-Tab Method

Housing Design: Final Recommendation

- The Tri-Hex design is the most promising
  - Rigid triangular structure
  - Compatibility for lens attachment
  - No adhesives required for construction
  - Simple assembly

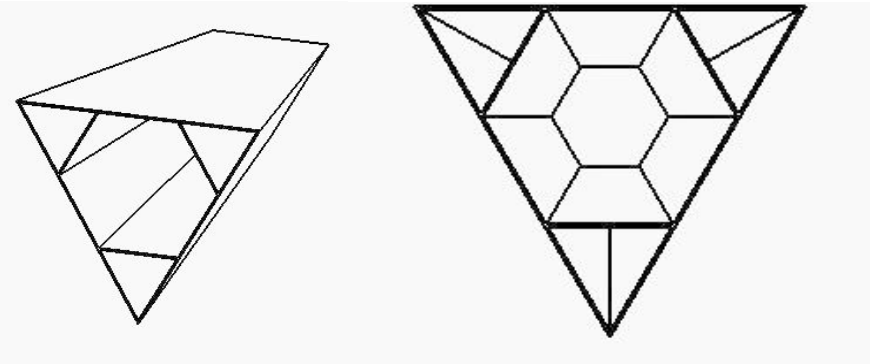


Figure 18: Tri-Hex Design CAD Drawings

Housing Design: Alternative Considerations

- Internal Truss Reinforcements
  - Paper or Plastic
- Limit Adhesive use
- Lens Attachment

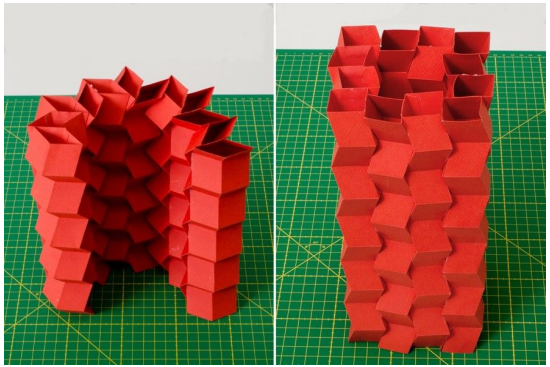


Figure 19: Zippered tubes design offers collapsible structures with large assembly time. [18]

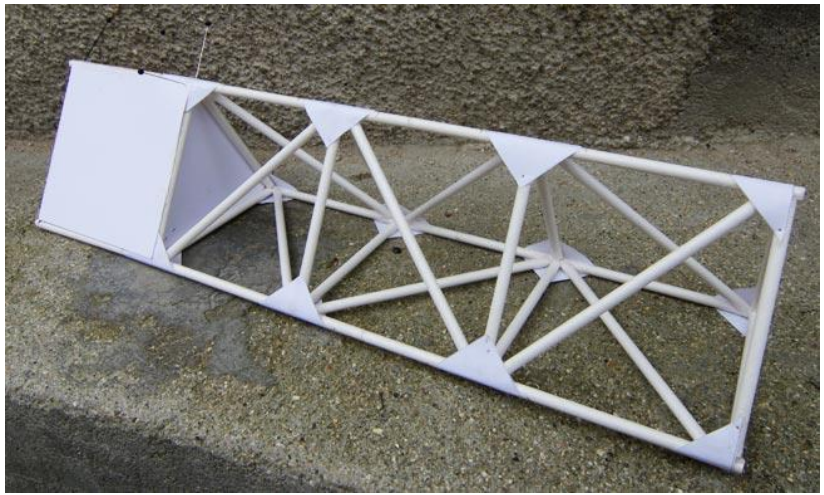


Figure 20:Truss model made from rolled paper. [17]

Housing Design: Manufacturing

- Glowforge Laser cutting printer [19]
  - Materials (cuts and engraves):
    - Paper, Wood, Leather, Cardboard, Rubber, and more.

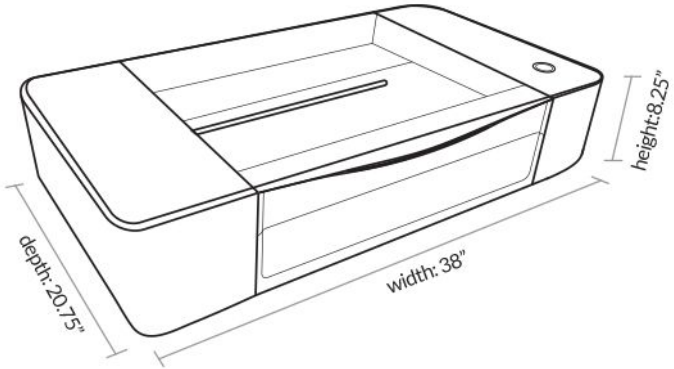


Figure 21: Contrast acrylic street map with location was made with the printer [19]

Housing Design: Testing

- Bending - Truss Load Test
- Twisting - Applying Torque at Ends
- Compression - Axially and Radially
- “Element Testing” - Sweat, Water, and other impacts on the product.

Figure 22: Simple load test typically used for bridge design. [20]

Current Cost Breakdown

Table 3: Initial Investment and Recurring Material Costs[16],[19].

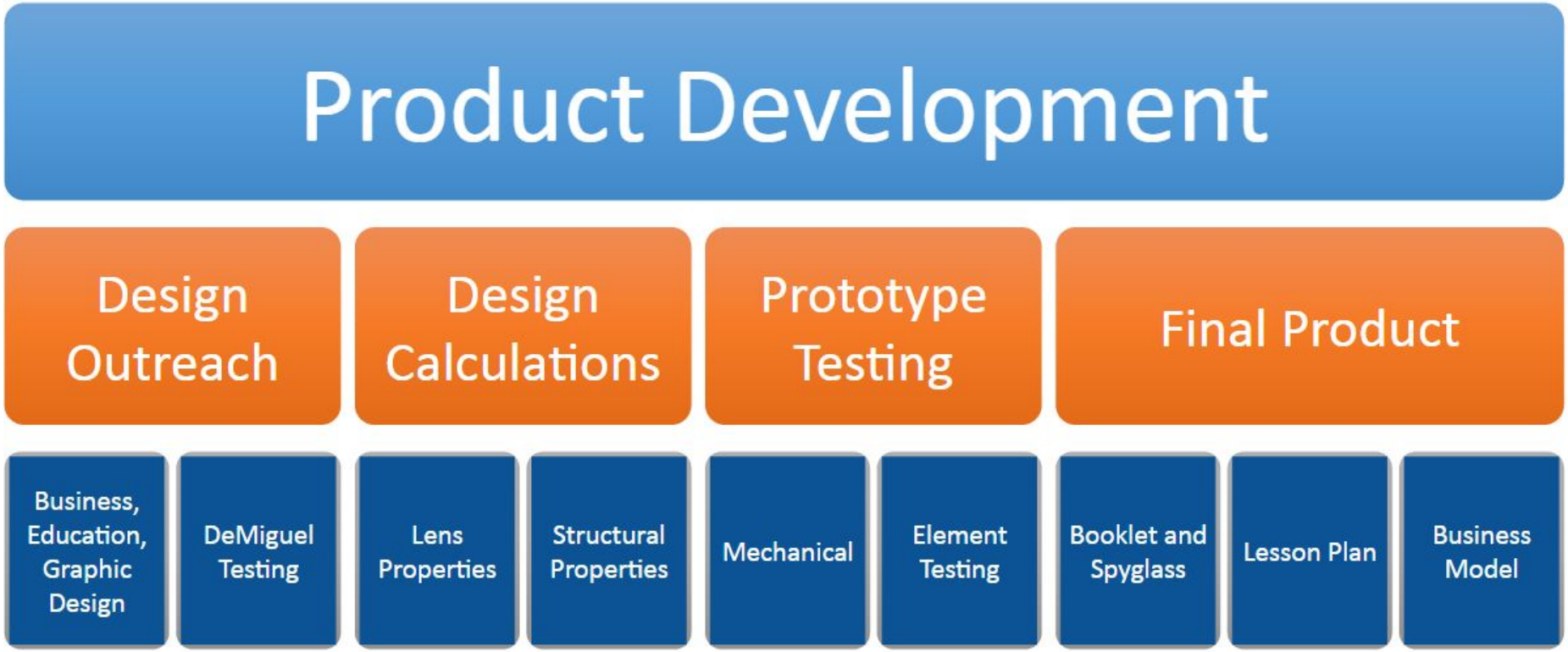
CAPITAL COSTS	Unit Cost	Quantity	Total Costs
Glowforge Basic	$2,395.00	1	$2,395.00
Form 1+	$2,799.00	1	$2,799.00
RECURRING COSTS (MONTHLY)			
Rental Workspace	$500.00	N/A	$500.00
Equipment Maintenance	$100.00	1	$100.00
Photopolymer Resin	$149.00	2	$298.00
Reams of Paper	$18.29	4	$73.16
		TOTAL CAPITAL COST	$5,732.45
		TOTAL RECURRING COST (MONTHLY)	$971.16

Risk management

- Manufacturing Equipment
  - Theft
  - Damage
- Community Investment
  - Education and Economic Applications
  - Manufacturing Labor
- Transparency
  - Accounting and Business Management

Figure 23:Risk Management [21].

Future Milestones:



Future Milestones:

Table 4: Important deadlines for next semester

Task	Duration (days)	Completion date
Business, Education, Graphic Design	6	August 30th
DeMigual Testing (Housing)	5	September 5th
Mechanical Test	3	September 23rd
Element Testing	3	September 26th
DeMigual Testing (Product)	5	October 3rd
Lens Properties	30	October 4th
Business Model	14	November 28th
Lesson Plan	14	November 30th
Booklet and Spyglass	56	November 30th

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Questions?

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