Utilizing the Engineering Design Process to 3D Print and Manufacture a Reconfigurable Tool-kit

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Motivation

- To create an innovative product that is functional, usable, aesthetically pleasing, and can be attached to a keychain.
- A useful multi-purposeful item for the ease of consumer.

Background Research

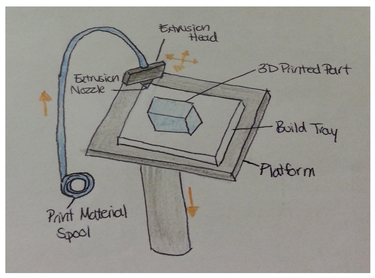
Reconfigurability

- A reconfigurable product is one that can be transformed to have an additional function. The one product can serve many needs.
- To transform the product there are different methods that can be used:
  - Expand and collapse is executed by changing the volume the item occupies. To raise or compress the object.
  - Expose and cover is executed by unveiling or covering up a surface.
  - Fuse and divide is executed by combining the two seperate items to form the reconfigurable product.

A reconfigurable chair and step ladder. [3]

How It Works: FDM 3D Printing

- FDM, or Fused Deposition Modeling, is a method of additive manufacturing or 3D printing.
- It uses thermoplastic polymers in the form of a filament to print an object.
- The material used in these prints is PLA.
- The 3D printer uses a heated nozzle to extrude material. The plastic is layered continuously. This is how each piece is made.



Properties of FDM Printing

- Shell parameters- The thickness of the shell should be larger than or a multiple of the nozzle diameter. The thickness of the shell influences the time it takes to print, the amount of material used, and the strength of the product.
- Infill parameter- The type of infill geometry and the percentage of infill influences its strength.
- 45° rule- Supports are extra material used to prevent a product from deforming when printing a piece that has any angle over 45 degrees. Adding supports can increase the cost and time and create a more rough exterior.

Reconfigurable System

- The box is a container for an allen key. The lid uses a sliding mechanism to open and close. At the base of the tool set is a phone dock that can be opened through the use of the hinge. The dock attachment as well as the base of the box allows one to rest their phone.

Methodology

Stage 1: Design Brief
- Developing ideas for a reconfigurable product.
- Understanding limitations of FDM technology and the material used, PLA.

Stage 2: Task Clarification Phase
- Establishing the purpose and function of the product.
- Determining if product is possible to print with the influencing factors; printing method, material used, and purpose of product.

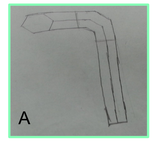
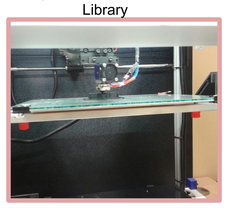
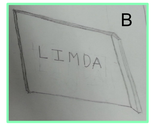
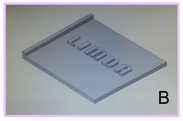
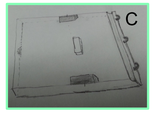
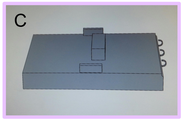
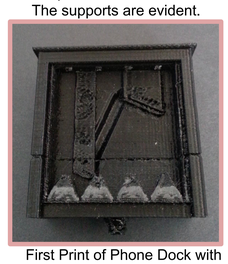
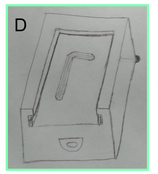
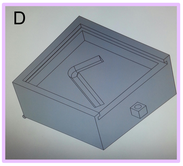
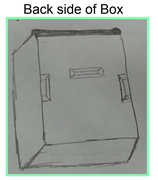
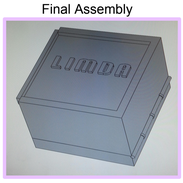
Stage 3: Concept Development
- Developing design to be within limitations of the printer and material.
- Selecting the concept design that is best suited for materials and printing method.

Stage 4: Detailed Design Phase
- 3D design on 3D modelling software, SolidWorks.
- Refining the design of product.

Stage 5: Manufacturing
- Prototype Print- First print using printers in Cameron Library.
- Post Processing- Removal of supports, sanding and refining.

Stage 6: Assembly
- Ensuring parts are able to fit within each other and can be reconfigured.

Design Progress

Concepts		3D Model: SolidWorks	Prototype
	A- Allen key		Printing of Prototype in Cameron Library 
	B- Lid		First print of Tool Box Base. The supports are evident.
	C- Phone dock		
	D- Tool Box Base		First Print of Phone Dock with supports
Back side of Box 		Final Assembly 	

Future Research

- Parts of the current printed tool are too small to print properly. Redesigning the hinge for the phone dock to be a better fit for the manufacture and assembly stages would improve its function.
- Developing an optimized product that is material and cost efficient.

References

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2. B.S Rupal, Rafiq Ahmad, A.J Qureshi. “Feature-Based Methodology for Design of Geometric Benchmark Test Artifacts for Additive Manufacturing Processes”. *Procedia CIRP*, Vol. 70, 2018, Pages 84-89.
3. Haldaman J, Parkinson MB. “Reconfigurable Products and Their Means of Reconfiguration”. ASME. *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, Volume 1: 36th Design Automation Conference, Parts A and B, 2010, Page 219-228.

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