Context

Background

Jewelry making is important to the people of D'kar as it is a part of their livelihood and their culture. It is a practice that has been passed down from generation to generation. Mothers teach their daughters jewelry making and their daughters pass down the tradition to their daughters. The men also take part in the art of jewelry making.

The items commonly used to make jewelry in D'kar are ostrich egg shells and glass beads. To be an ostrich egg shells jewelry maker, one needs a license to acquire the ostrich egg shells legally. The glass beads on the other hand can be acquired at the local crafts shops. However the glass beads are expensive. The size of the beads are also limiting as they don't offer a variety of designs and shapes. Jewelry makers are interested in making their own glass beads, but they didn't know how to go about the technical process of making glass beads. In other countries, glass beads are made using firewood. However, firewood is a scarce resource in D'kar. Using firewood would also be harmful to the environment. An alternative energy source that is abundant is the sun.

Solar energy can be used to melt glass to make glass beads. Glass has a high melting temperature of up to 880°C. To get to these high temperatures, a Fresnel lens is used to focus the power of the sun to a focal point where the glass is melted. A Fresnel lens consists of a series of concentric grooves that have been etched on plastic, which replaces the curved shape of a typical lens. In this case, the Fresnel lens would be used as magnifying glass. The solar glass bead furnace uses the Fresnel lens to melt glass and form glass beads.

Community description

D'kar has a large community of jewelry makers. They display their handiwork at trade shows and local competitions. Jewelry making is used as a source of income generation and also as a hobby. From the interviews that were carried out, we found out that it is a practice that is passed down from generation to generation. It was also seen that the only place that they could purchase the glass beads were from the local crafts shops. The community that would be using this machine is the jewelry makers of D'kar and possibly the local crafts shop.

Key stakeholders and typical users

The key stakeholders of our project are listed as follows:

- Jewelry makers
- The environment
- The local crafts shops
- Amy Smith

The typical users of our product would be jewelry makers, local crafts shops owners, and jewelry shop owners.

PATH Statement

Jewelry making in D'kar is important to the people's livelihood and culture. The jewelry is commonly made using ostrich egg shells and glass beads. However, glass beads are expensive to buy from the local craft shops and this sometimes hinders the jewelry makers from meeting the demand of the jewelry. In other countries glass beads are made using a firewood furnace, however, firewood is a scarce resource in D'kar. We are introducing a solar bead furnace which will harness the power of the sun and use it to make glass beads. With the solar bead furnace, jewelry makers in D'kar can customize their jewelry by making molds to make their own glass beads that will carry their identity and the culture of the people of D'kar.

DESIGN PROCESS

A design process is a series of steps that designers/ engineers follow to come up with a solution to a problem. Many times the solution involves designing a product or a service that meets certain criteria

and/ or accomplishes a certain task. Firstly, a designer needs to learn, ideate and experiment and evaluate. Learning involves gathering information and realising it to come up with insights. As part of information gathering, we went on to research on jewelry making in D'kar. There were different stakeholders like jewelry makers, local shop owners and the community. The information was mainly focused on how glass beads are acquired in D'kar, how much it costs to make jewelry and whether the jewelry makers are open to owning a bead making machine. From the gathered information, we came up with ideas on how we are going to use solar energy in the machine and also the type of design of the machine. The first approach taken was to propose a way of melting glass before coming up with the design of the machine. In all ideas that we came up with, we narrowed it down to three concepts which satisfy parts of the design requirements. Choosing an idea does not mean it is perfect. With that we made several experiments to further iterate the models. After iterations and analysis we came up with one design that covers most requirements. The experiments included testing of the size of the machine with respect to human/user, proper placement of the mold and easy use of the machine.

CONCEPT EVALUATION

Datum

Uses the swing mechanism of the lens with the frame attached to the mould holder for a fixed focal distance for easy location of the focal point (mm).

Concept 1

It uses a swing mechanism of the lens frame but emphasises more on safety of the user by using covers to shield exposed light and mechanisms for ease of use.

Concept 2
It uses the swing mechanism for the lens according to the direction of the sun.

	Criteria	Datum	Concept 1	Concept 2
Specific	Quality of beads	0	0	0
	Quality of material	0	+	-
	Quality of lens	0	0	0
	Lens closing time	0	+	-
	Light exposure	0	+	-

General	Ease of use	0	+	-
	Safety	0	+	-
	Cost	0	-	+
	Simplicity	0	-	+
	Aesthetics	0	+	-
	Easy access to materials	0	-	+
	Total	0	+3	-3

ANALYSIS AND EXPERIMENTATION

All concepts were analysed according to the design requirements and the concepts which met most requirements was chosen to be developed further with user feedback. The analysis was focused more on the safety of the machine, quality of beads produced, the time to close the cover of the lens and the ease of use of the furnace. The first phase of the experiment was to test the ability of the lens to melt glass particles and the type of glass to melt easily. The experiment produced positive results because the glass melted in less than a minute and beer bottles proved to be more effective in melting under a minute. Powdered glass proved to melt faster because of increased surface area of glass particles.

The second experiment was analysis of the time to close the cover of the lens as a safety issue. A closing mechanism was built into the machine as close as possible to the control lever in order to reduce the time to close the cover. It takes one move of the hand to close the cover.

Safety of the machine is also a requirement because the lens produced a beam of light that can damage bare eyes of the user secondary users. A removable cover is used to cover the area of the mould holder and there is also emphasis of using welding goggles to cover the eyes.

There are mechanisms which are implemented into the machine in order to easily control the machine with less human power. Several mechanisms were tested with sketch models which mostly involved the swing mechanism of the frame and the rotational movement of the table.

USER NEEDS AND DESIGN REQUIREMENTS

User need	**What are you going to measure**	**How to measure it(units**	**Good value**	**Better value**
Safety	• Time to close the exposed lens	Time in seconds	<10 seconds	<5 seconds
	• Removing the mould from the target.	Time in seconds	<10 seconds	<5 seconds
	• Exposed light	Distance(mm)	$<10^4$ m	$<2x10^4$ m
Affordability	• Cost of bead making	Pula		
	• Cost of making the machine	Pula		
	• Payback period	Time(years)		
	• Access to materials for making the machine.	Distance(km), location		

Quality	• Quality of beads	Thermal stress of glass(°C/mm^2)	<5%	0%
	• Quality of lens	Focal point(mm) Temperature(°C)		
	• Quality of material	Durability(Years)		
Aesthetics	• Colour	Customer's choice	Our choice	Customer's choice
	• Size	Small to big		
	• Shape	Customer's choice	Our choice	Customer's choice
	• Pattern	Customer's choice	Our choice	Customer's choice
Comfort	• Working height	Height (mm)	95^{th} percentile male	5^{th} percentile female
	• Working posture	Sitting or standing	95^{th} percentile male	5^{th} percentile female
Functionality	Production rate	Number of beads per day	100	Many

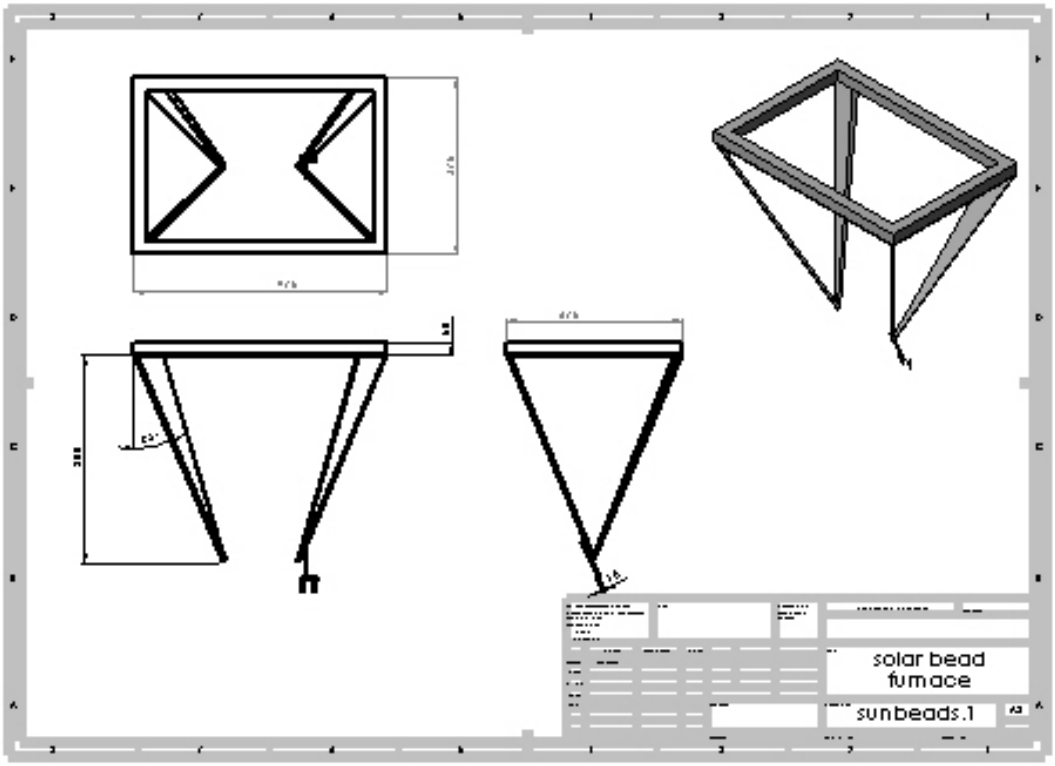
HOW IT WORKS

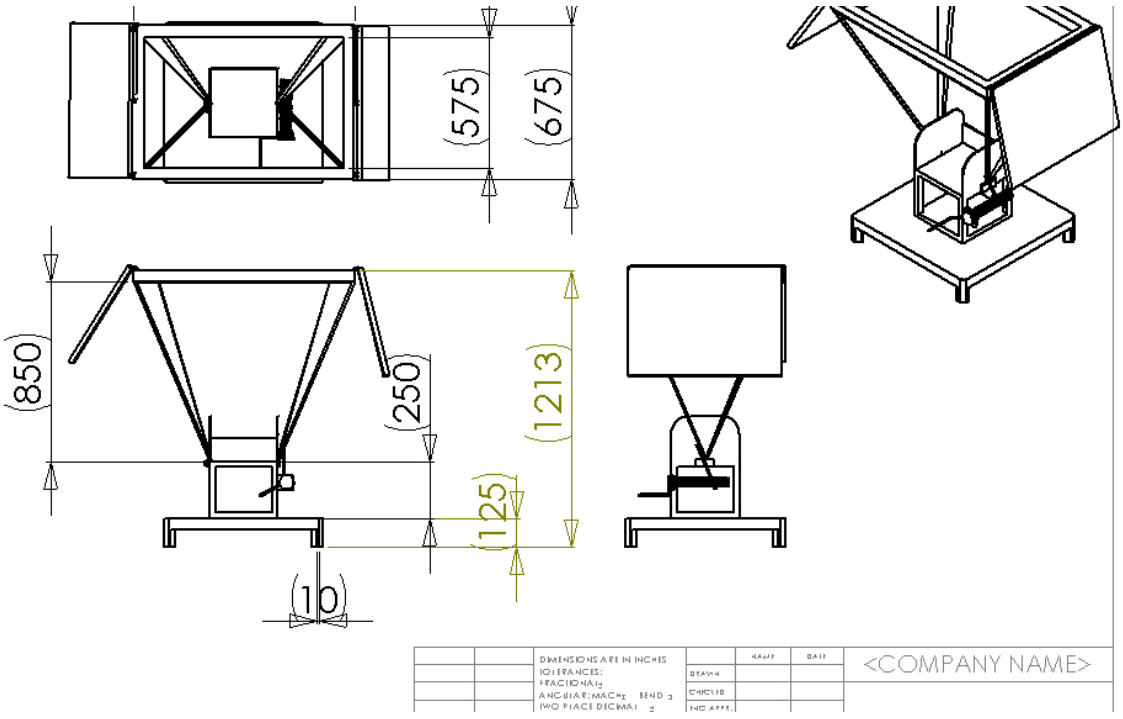
The machine uses a lens to focus light into a pounded glass on a mould to melt the glass to create a bead. There are four mechanisms which are rotation, up and down movement, swing movement and lever mechanism. The rotation movement is for rotating the lens frame to focus on the direction of the sun. The up and down movement is to adjust the focal distance of the lens and the swing mechanisms is to focus the lens in the direct sun rays. All these mechanisms are necessary for the stability of the machine and for the ease of use of the machine. After setting up all the parameters of the machine, crushed glass which is placed in a mould is then placed on the focal point(with the lens still closed to avoid getting in contact with the heat produced). When the mould is in place, the lens is opened by pushing the lever which is then closed immediately after the glass melts. A hole is then made with a nail while the glass is still in a molten state. For more safety aspects of the machine, there is use of tongs to remove the mould from the table because it also gets heated up by the heat from the lens.

Up and down mechanism using a screw for adjusting the focal distance.


Spring mechanism for adjusting the direction of the lens or for a swing movement.

CAD DRAWINGS
Initial CAD drawings





PERFORMANCE

From all the iterations done to the furnace there were still positive and negative aspects of the machine. The most important part of the machine was the safety of the users as there are covers which blocks light and lever control to quickly close the cover. The mechanisms required more human power to operate because of the weight of the frame. The beads produced were also not of good

quality because they were breaking after removal from the mould and this is because of rapid change of temperature. After evaluation of the machine, more iteration was done to the swing mechanism which changed from a screw movement to a spring movement because it is lighter to operate than using a screw. The quality of beads is also moderate because of the use of available materials. Several materials are being explored at the moment as a solution for producing better quality of beads (e.g. D'kar sand).

TOOLS AND MATERIALS REQUIRED

Tools

- Spanners
- Welding machine
- Metal grinder
- Measuring tools
- Drilling machine

Materials and Sizes

- Zinc sheets 1.5sq meter
- Screws 1", ¾", 10cm
- Washers 38mm for inside rubber feet
- Metal wire 5mm
- Rubber feet 38mm
- Spring
- Cardboard 1msq
- Square tubes 10mm
- L profile 3m
- Paint ox prima paint and two cans of spray paint

Lessons learned

Community engagement

From the interviews that were carried out, the jewelry makers wanted to make their own beads but they had no idea on how they would go about it. They liked the idea of owning a machine that could make the beads as it would reduce the cost of making the jewelry. They also felt like they would make a profit as they would not need to spend a lot of money purchasing beads.

Members of the D'kar community also felt like having access to all the technology at the innovation center would expose the youth to new concepts and ideas, as well as encourage other members of the community to start their own enterprises. They encouraged the local champions of the projects to carry the same spirit forward and share their knowledge with other members of the community.

User feedback

The people were mainly concerned with the safety of the machine. The first prototype was open and the people were concerned with the bright blinding light being too exposed for any passersby to see with their naked eyes.

The people were also concerned about how safe it would be for them to make holes in the melted glass without burning themselves as they would be exposed to high temperatures.

The people also liked the beads; however, they wanted molds that would produce the smaller beads that are used to.

The people were also concerned with the size of the machine. One woman talked about buying the machine and she wanted it to be smaller and portable for her to carry to her home.

The people were also concerned with how much time it would take to make the glass beads. One person suggested using a larger lens to make many glass beads at the same time.

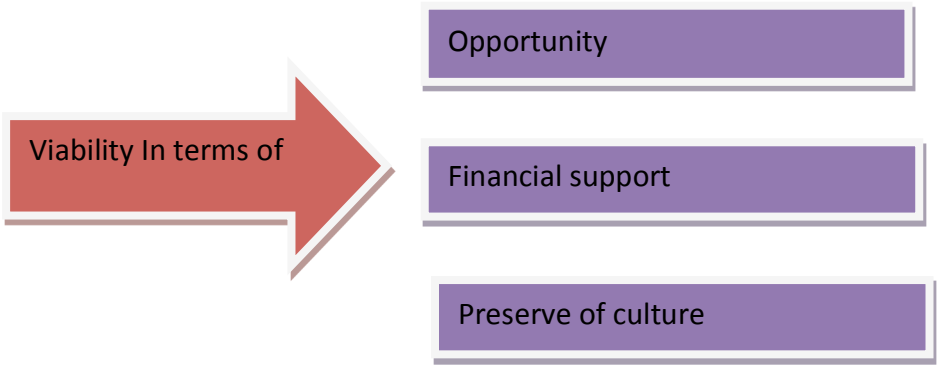
Troubleshooting

Some of the tests that were done on the machine included:

- Stability tests. The frame of the machine was heavy, and so we came to the conclusion that some adjustments needed to be made.
- We had to find the exact focal point of the lens by adjusting the height of the lens.
- The frame and the mold table needed to be adjustable and so we created a table that would be able to revolve 360° so as to ensure the sun and the lens were in a linear position.
- We made molds using different kinds of soil some of which included; termite clay, sand and a combination of sand and clay. Initially, the heating was done on the molds before heating and they cracked. However, the strongest molds were the ones made from termite clay.
- We also experimented with ash and baby powder as a substitute for kaolin clay. We found that ash was a better substance to use as the glass bead would not stick on the mold and it also made it easy to remove the nails that were used to make the holes in the beads.

Next Steps/Project Future

- **Reflection on project viability and other design opportunities:**
  The project came up out of the need of the community. The project is viable as it will solve the community's problem and open many opportunities for the users and stakeholders. As making jewelry of glass beads is a common practice of people in D'kar for their livelihood, it will solve the purpose of making glass beads of their own rather than getting it from the shop which is expensive. They not only can make the glass beads but can also make different shapes of beads which are close to their culture. Till now we have succeeded to make the circular beads only but there are possibilities of making different shapes and sizes with different molds and also with different materials. New design of mold can be done in future.



- **Continuity/dissemination model**
  The project will continue with the local champions and all other participants will be involved through social media and emails. The local champions will carry forward the project. The improvement will be done here in Dkar with the ideas of all the participants. We will engage the University of Botswana students in the project and those that have a special interest of renewable energy for further improvement. The group will connect to other participants and peoples who are involved in such activities to get more inputs. The community will test the machine in each step and give their feedback so that we could improve the project.

- **Action items for the next few weeks; action items for the next few months (including who is responsible for completing them)**

In next week most work will be done to develop the prototype. Training of people including our local champion on how to use the machine and find out potential user. To identify whether community are interested to own the machine or they want to use it only at the innovation center. Thought on to start an entrepreneurship model if possible. In the next few months work on trying to build more molds using different material. We will try to solve the challenges involved with the existing prototype. The group will take the prototype to the next level with the help of MIT lab students or with the engagement of the University of Botswana. More work will be done on choosing proper glass, mold to produce good quality of beads.

- **Anticipated risks and challenges**

  After the mid presentation, most of the community member gave feedback on the safety issues. So we worked on it and provide a lever to adjust angle and wing nut for height adjustment and a separate lever to cover the lens for more safety. But still there is a risk of safety in terms of user and people around the machine. One of the major challenges for us to make good quality of beads. At present we are able to make one bead at a time so we have to find a method to make more beads in less time.

- **Anticipated needs for mentors and partners**

  We need help in design aspect, engineering and also in business.

  - ✓ Need for engineering aspect-Repairing and choosing of proper material for the prototype.
  - ✓ Need for design aspect- Design on beads and mold. Coloring of the glass.
  - ✓ Need for business skill-Marketing of the product and the services.

Apart from that it would be good if people from D-lab could help work on bead quality and design and also in marketing opportunity. For a mentor it would be nice if he/she could have knowledge in bead making, bead coloring and mold making.

We have experimented with sand and got some good results. At the moment the sand bead is very brittle but more experiment can be done in this direction.