open
MARCH 25-27, 2010
SAN FRANCISCO

PEER-REVIEWED PAPER

Design with the Majority: The Collaborative Design of a Cargo Bicycle for Uganda

Jason A. Morris, Assistant Professor of Industrial Design, Western Washington University

Abstract

This paper describes the exciting and rewarding process of a bicycle design that was created in collaboration with Ugandan bicycle couriers. In Uganda, many residents use low cost, poor quality bicycles as their primary means of transportation. The design process started with a connection to an American resident of Uganda. This mediator formed a "design team" of Ugandan couriers, who gathered regularly and discussed the ideas the designer had for a new cargo bike design. After several iterations on paper, and communication through email, a design was finalized and an initial prototype was made. The designer then traveled to Uganda to meet the couriers and to have the bike tested and critiqued. Through the successes and failures, valuable lessons were learned regarding the design of products for people of developing nations.

Introduction

In Hoima, a small community in Uganda, Africa, many residents use bicycles for transportation. Only the very prosperous can afford to purchase a car or truck. Whether it's to deliver goods to the market, or to carry water from the well to their home, they rely on a traditional bicycle for their transportation needs. However, the bicycles that are available to them are unreliable, inefficient, heavy, incapable of carrying cargo, and generally of very poor quality.

Figure 1. A bicycle courier (Boda-Boda) cyclist pushing a loaded Hero bicycle in Kampala (left) and giving a passenger a ride (right) in Hoima, Uganda.

Objectives

The outward objective of this project is to design and develop a low cost utility bicycle with rural Ugandans as the target user. The solution could be appropriate throughout East Africa and other parts of the world with similar conditions. The eventual goal is to convince a manufacturer to produce and distribute this bicycle design to developing countries. In order to generate interest and gain credibility, the design must be practical, manufacturable, unique, and feasible. The bicycle must be able to carry loads up to 300 pounds, in addition to the rider. It must withstand the rugged roads and conditions of the environment. It must be strong and durable, with minimal maintenance. The most difficult constraint to meet is a retail target cost of less than $80 USD, which is comparable in price to the current Indian and Chinese bicycles available and is roughly equal to two months of income for potential users.

The underlying research objective of the project is to learn about what it means to design for people of a developing country and of a different culture. How can a Westerner design an appropriate and successful product for an African? What are the challenges and obstacles? Are people the same all over the world in terms of their relation to the products they use? What design process works? In order to answer these questions, intensive research was done in multiple areas: hard facts about the country, the environment and conditions present, the intended user, the existing bicycles in use, the infrastructure of repair and maintenance, and the culture of the user.

Research

The chart below highlights some contrasts between the US and Uganda:

Statistical Contrasts	USA	Uganda
GDP per capita	$46,000	$1100
Fertility rate	2.1	6.8
Infant mortality rate	.006%	.07%
Population HIV / AIDS	0.6%	4%
Population under 15 years old	20%	50%
Life expectancy	78 years	52 years
Population	303 million	31 million
Geographical size	9.8 million sq. km.	.24 million sq. km. (size of Oregon)
Agricultural labor force	0.6% of population	82%
Internet users	69% of population	2.4%

Table 1. Statistical Contrasts between the United States and Uganda (CIA 2008)

Most Ugandans are subsistence farmers. Health care is inadequate, so major infectious diseases are a very high risk and include hepatitis A, typhoid fever, malaria, plague, African sleeping sickness, and schistosomiasis. A paved road is a rare treasure to find in Uganda, for only 22% of the roads are paved and the majority of those are in its capital, Kampala. Most roads are rough red dirt and clay, which get extremely slippery when wet. When dry, the fine clay dust fills the air, making visibility difficult.

The User: The Boda-Boda

A Boda-Boda is a person who gives passengers rides, or delivers goods on his bicycle or motorbike. He is essentially a two-wheeled taxi driver. The name may come from the word "border," as they may take you across a border. Or it may come from the puttering sound of a motorbike. Either way, the Boda-Bodas are a prominent form of public transportation in East Africa. They are everywhere, hanging out on street corners, under the shade of trees, sitting on their most valuable possession and their primary source of income: their bicycle.

Boda-Bodas start out with a bicycle and deliver passengers or goods for a small fee. A short in-town ride might be 200 to 300 Ugandan shillings (15 cents US). They carry passengers more frequently in the rural areas and small towns. They attach a vinyl-padded cushion on the rear rack and bring children to school or businesspeople to their offices. In Kampala, the bicycles are more likely to be beasts of burden, acting more like a two-wheeled wheelbarrow for loads of goods. Fruit, firewood, 50 kg. sacks rice, full-size steel bed frames, 5 gallon jerry cans of water, and whatever else one can imagine. In Kampala, one bike was seen being pushed through traffic with six 50 kg. sacks of sugar (totaling 300 kg./660 lbs.) loaded on the back.

The Hero Bicycle

The most common vehicle throughout the country is the black Hero bicycle. This design was originally built in 1913 for the British military, and has not changed since. The Hero is made in India and shipped in pieces. The bike can be assembled anywhere with a minimum of standard tools. It is sold at retail for about 110,000 UGX ($65 USD) assembled. The quality of the bike is extremely poor, worse than the American equivalent of a department store bike. The bike is a roadster style with 28-inch wheels, a single-speed freewheel, steel rims, a heavy gauge steel tubing, and levered rod brake system. It weighs about 45 lbs. with a rear rack. Its gearing is much too high for even the slightest uphill grade. The parts are made with such low tolerances that there is no hex nut that is quite the same, and none seem to fit a standard wrench size, English or metric. The steel is a low-carbon soft steel that easily bends or distorts. The steel-rimmed wheels are out of true even when new. The geometry of the "cockpit" is constrained and awkward, but that is partly due to personal convention. There is only one size available for the Hero, and it is too large for the majority of East Africans (who tend to be a couple of inches shorter than the average American). The primary asset for the Hero is its ubiquity. One can find the exact same model and its parts throughout Africa. Considering that they seem to be constantly breaking, this becomes an extremely important factor.

Bicycle Shops and Parts Availability

The bicycle shops in Uganda are about the size of a large closet or shed and are open in front, with a counter and walls filled with shelves and spare parts for the Hero bicycle. Only one tool is generally in evidence: a flat steel multi-purpose wrench with the intention to fit all of the nuts on a Hero bicycle. One can find tires (28 and 26 inch), chains, air pumps, patch kits, ball bearings, inner tubes, bells, bearing cups, brake parts, forks, and most Hero parts. Low-quality mechanical tools such as adjustable wrenches, screwdrivers, and crescent wrenches can be found at automotive/hardware shops. The availability of such tools and parts was important to consider in the design of the bicycle.

Figure 2. A bicycle shopkeeper in her store (left). A man lacing and building a wheel (right).

The Design Process

The design process started with a connection to an American resident of Uganda, Reverend Shirley Morris of the Anglican Church. Through this relationship with Rev. Morris, an important conduit of information and research was available to inform the initial stages of the design. Rev. Morris was a regular passenger with the Boda-Bodas for personal travel and had developed friendships with them. Several community members, as well as Americans who had visited Uganda, noticed a need for a better bicycle.

Rev. Morris became a mediator between the American designer and the Ugandan users. She formed a "design team" of Ugandan couriers who gathered regularly for lunch to discuss the ideas the American designer had for a new bike design. Drawings were emailed to Rev. Morris and printed in Uganda, reviewed, and critiqued by the Boda-Bodas, who then sent their comments back to the US. For almost two years, designs were proposed, revised, refined, and changed through these lunchtime meetings. After several iterations, a design was finalized and a prototype was made in the US. The designer then traveled to Uganda to meet the couriers and to have the bike tested and critiqued.

Prototype 1.0

The first prototype design is essentially an elongated mountain bike with an integrated rack. The front geometry has a comfortable mountain bike arrangement with a low stand-over height, rigid fork, and 26-inch front wheel. The 20-inch rear wheel has been moved back, increasing its wheelbase 10 inches, which allows for a more distributed load between the two wheels and provides more area for loads and passengers. A rear rack has been designed to be integrated into the welded frame and is in the form of a tetrahedron. This is a very structurally rigid and lightweight form.

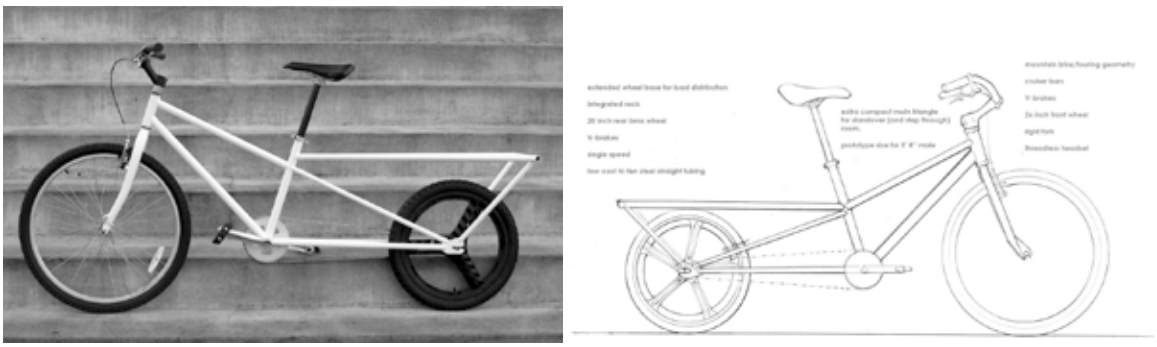

Figure 3. Prototype 1.0. and Prototype 1.0. Illustration

All extraneous parts and accessories were omitted. The rear wheel uses a coaster brake hub to eliminate rear cables and brake pads, and to reduce maintenance. The drive train is a simple roller chain, single-speed freewheel and is geared low to roll at 12 mph at 90 rpm (3.7 m. (145 inches) per revolution development). A small rear wheel allows for a lower platform and center of gravity for carrying cargo. This would be advantageous for some types of low-density cargo, such as firewood or charcoal, and is stacked high on the bike. A small 20-inch wheel is structurally stronger, but has higher rolling resistance than a 26-inch or larger wheel.

Relationships

The designer spent a majority of the time in Uganda building relationships with a group of Boda-Bodas. This group of ten young Ugandans had formed an organization, the Hoima United Riders Association, which was a community of colleagues that supported each other in their professions and their families. These men were open, friendly, and adopted the designer into their community. They invited the designer to visit their homes and meet their families. Their small homes are typically made with a wood framework and mud or homemade brick, a corrugated steel roof, with no glass windows, no plumbing, no electricity, and four small rooms. The designer was honored to visit all ten families at their homes, eat with them and meet their numerous children, and was given generous gifts, such as sugar cane stalks, pineapples, avocados, and live chickens. The designer spent nearly every day with these men over the course of three weeks. This contact allowed him to learn about them, their concerns, and their culture. This experience was invaluable in revising the bicycle design.

Figure 4. The designer with Patrick, his two wives, and twelve children in front of their home in Hoima (left). Discussing the difficulties of brake adjustment (right).

Reactions and Revisions

Figure 5. First bicycle prototype test with 3 passengers. Debate and critique of the design.

Meetings were held with many different Ugandans in Hoima to test ride the bicycle and discuss ways that it could be improved and features that they liked. Positive comments were received on its light weight, lower gear ratio, performance of linear brakes, riding comfort, color, and its ability to carry loads. Negative

reactions were received regarding its different sized wheels, the lack of a chain guard, the rear platform low height, its need for foot pegs, and its lack of compatible parts availability. Everyone was open to new technologies, such as linear pull brakes and quick release skewers, as long as there were compatible parts available. "How much will it cost?" and "Can I get spare parts" were the most commonly asked questions. The bike performed well through many rides on the rough roads around Hoima, and was used frequently with passengers.

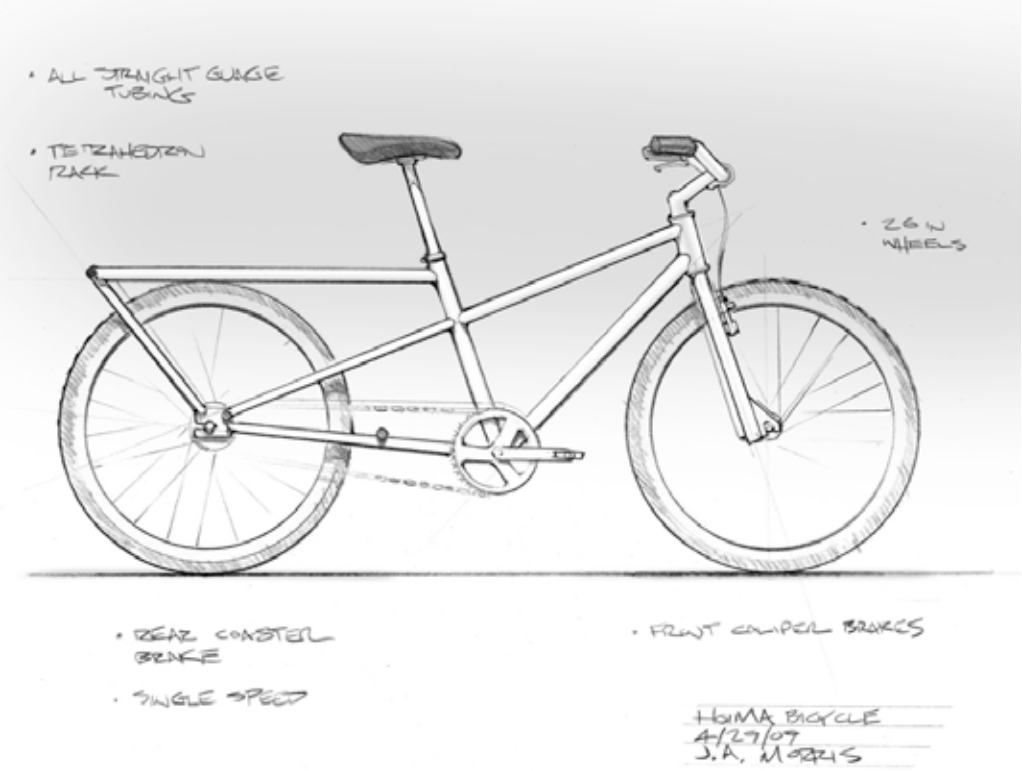

Figure 6. Version 2 of the Hoima Cargo Bicycle

Hoima Bicycle Version 2

Tristan Allen and the Bicycle Sponsorship Project and Workshop NGO have established a small frame-building workshop in Jinja, Uganda to create the next version of the Hoima Bicycle. The design was revised according to the feedback and lessons learned from the first prototype (see figure 6). In 2009, with local Ugandan welders and fabricators, the BSPW manufactured three frames and built them as complete bicycles using parts and steel found in Kampala. This second version of the Hoima Bicycle has been tested by Boda-Boda in Jinja, Uganda with passengers and loads. It has performed well and Ugandans have expressed their pride in the Ugandan-made bicycle. However, some obstacles remain with the local production of a bicycle frame. Good quality steel tubing is not currently available to purchase in Kampala, so low-carbon steel tubes, which are less rigid than high tensile or chromoly steel, had to be used. This led to a frame with less structure and stiffness. The parts used came from donated, used recreational bicycles that have been shipped from North America and Europe. This is not a reliable supply source, so importing parts would have to be arranged. Otherwise, Indian Hero parts would have to be specified. Even with these low quantities, the bicycle could be made for under $90 USD in parts and materials. However, detailed figures were not available from BSPW. Although much was learned about starting such a venture, the long-term impact and acceptability has yet to be seen.

Lessons About Designing for East Africans

Cultural contrasts

A number of important lessons were learned from this experience, the first of which was the realization of the difference of cultures and how it affects product design. Designing for another culture requires an understanding of the culture and how the people think differently. East Africans are culturally different from Americans in some obvious ways and some puzzling ways.

In Uganda, the community needs come before those of individuals. Friendships and family come before career. Saving money is considered hoarding and selfish, because someone in your community could need it now. A Ugandan invests in their friends and family, because when all else is lost, those are the people that you can rely upon. This mindset seems to come from a long history of poverty and disasters. (Maranz 2001)

It seems that nothing is reliable in a Ugandan's world. Politicians are corrupt and expected to be so. Being bitten by the wrong mosquito could mean contracting malaria and dying a week later. Drinking the wrong water could mean a life-threatening disease. A job may be here today and gone tomorrow. That employer may pay you, or may not and disappear. The rainy season may come early or late, or you may have a drought and your family will starve. Electricity for an entire town is turned on and off at random times by the power company. If you are injured and go to a hospital, the doctor may be there, or may not, and no one knows when or if they will show up to work that day. All of these are accepted facts of life for a Ugandan, but are maddeningly frustrating for an American. This unreliability leads to awareness that life is very short, random, and unpredictable. This awareness affects decision-making with regard to long or short-term benefits. The immediate need is addressed over the long-term need.

With regard to products, the story is the same, and price seems to rule over all other aspects of a product. Shops are filled with a limited selection of the lowest quality, barely functioning products imaginable. These are all made in China or India with the lowest standards in order to meet the lowest price possible. The only equivalency that one might find in America is the products in a discount "dollar store," but even those are higher quality products. This low standard for quality affects how a product may be designed. One of their first questions concerning the bicycle design, was "where can I get spare parts?" This reveals the implicit expectation of broken parts. A great limitation to design decisions is the lack of available replacement parts and tools for maintenance and repair. Many well-intentioned "designs-for-the-majority" are abandoned once they cease functioning because of this limitation.

Ugandans are extremely cost- and value-sensitive. Most are subsistence farmers and don't have much, if any, extra money to spend on products. The education of their children is a priority, so school fees take precedence over any other product beyond food, clothing, and shelter. Because of this, careful consideration is taken when comparing a lower cost product with a higher cost one. Unless the advantages of the higher cost option are abundantly clear, and others in their community confirm it, the lowest cost item will be chosen (Aguiar 2007). This phenomenon is congruent with their attitude about meeting immediate needs first. Products are also commonly shared, such as bicycles and cell phones, and consequently experience heavy use.

Respect for the community

Designing for another culture requires respect and meaningful egalitarian relationships with the people of that culture. The design process should include the people who are the target users. Including Africans in the design process not only enriched the design but also encouraged the community to feel important. The Ugandans took great pride in their role as advisors during the design process. They told everyone in their community and even announced it on the radio. They waited with great anticipation for the arrival of "their" bike. The day it was taken out of the box, they rode it into the center of town and proudly waved

to all of their friends. This collaboration lifted the social status of this group of bicycle couriers, and it gave them a stake of ownership in the project.

Leapfrog or stay compatible with technology

A designer must decide whether their new design is going to specify the newest or old, existing technologies. A new technology would perform better, but would be incompatible with the existing infrastructure, leading to a very short product lifetime. An old technology may not work as well, but it would be understood, acceptable, and would have compatibility with available parts and tools and therefore be repaired and used for a longer time.

A successful example of technological leapfrogging is the cellular mobile phone. Uganda has limited wired land phone lines. Only the wealthy and businesses can afford to install and pay for a landline. However cellular phones don't need a line to be installed to every house and hut, so it made sense to install cell towers and sell mobile phones. This has proved to be very successful in Africa, and many residents now own or share cell phones.

Figure 7. Repairing a Cottered Crank Arm on a Hero Bicycle. Hoima.

With bicycles, the situation is different. For the past thirty years or more, the exact same Hero brand bicycle has been shipped to and sold extensively in Uganda. Although its component parts are peculiar, poorly functioning, and outmoded, they are available everywhere, even in small towns. The brakes, for instance, are barely functioning, use dozens of parts, are hard to adjust, and must be disassembled to remove the wheel. But, in streets of Kampala you can see people cutting apart old auto tires into little chunks, inserting a screw through the center and selling replacement pads. So the question becomes, do you choose the superior modern linear pull brakes, which are easy to use, simple, and effective, over their antiquated rod brakes? And if so, where will people find spare brake pads if no shops carry them? Conversely, how can you convince bicycle shops all over Africa to carry these new brake pads when there are no bicycles that use them yet?

It seems that there are three options. One option is to stay compatible with old technology, which would lead to greater acceptance, but may not offer significant improvement. Second is to use the latest superior technology, which would require substantial investment to flood the market with compatible parts, tools, and support services. Third is to cleverly improve the performance and design, yet use existing parts, tools, and technologies. This is a significant design issue when designing for a developing country. To buy a newly designed product has much more serious ramifications than one would expect.

Design for income generation

A product that offers more convenience or time savings isn't compelling to people at the bottom of the pyramid. Convenience is the luxury of the rich and not a priority of the poor. This is expressed in the old

adage: "the African has no watch, but they have the time. An American has a watch, but hasn't any time."

A manual sewing machine is a good example of a product that could use a re-design. A manually powered Singer machine from 100 years ago is still more useful and valuable than the feature-rich, well-styled, electrically powered modern sewing machine. The old Singer doesn't need electricity to run, and it can help earn money, paying for itself in income generation. If one could have a low cost, manually powered sewing machine, that's easy to use and repairable, one could have a business. This business could pay for the children's education or health care or medicine or food, and may represent the only way out of the cycle of poverty.

Conclusion

Designing products for people of developing countries can be done appropriately with intensive research, cultural understanding, meaningful relationships, collaboration, and respect. If the users can be involved in the design process, the experience leads to shared ownership and increased credibility within the culture. With appropriate management, funding, and manufacturing support, this bicycle design has the potential to be very successful in the African marketplace.

References

Aguiar, Marcos, et al. 2007. Decoding the next billion consumers. *The Boston Consulting Group, Inc.* http://www.bcg.com.

Central Intelligence Agency. 2008. *CIA world factbook*. https://www.cia.gov/library/publications/the-world-factbook/.

Maranz, David. 2001. *African friends and money matters*. Dallas, TX: SIL International.