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Abstract

Over 783 million people lack access to clean water, and of these, 3.5 million die every year as a result of inadequate water supply, most often because of poor sanitation and hygiene (UN Water, 2013). While there are thousands of solutions that have been developed for cleaning water in various parts of the world, from high tech chemical processes to low-tech filters, the problem of unsafe drinking water still persists. This paper argues that one of the reasons for the disconnect between the problem and proposed solutions is a lack of systems design in developing robust models for distribution and adoption. Using a Canadian-led research project based in South Goa, India, called the CleanCube Project as a case study, this paper explores how localized systems thinking can lead to clean water solutions by leveraging income generation and women's empowerment activities. As part of this design research project, these strategies are being employed in communities where the need for clean water and improved sanitation goes hand in hand with a lack of economic and social enfranchisement opportunities, especially among women.

Introduction: The Challenge of Clean Water

According to UNICEF, in India alone, approximately 600,000 children die annually due to diarrhoea or pneumonia, often caused by toxic water and poor hygiene (Harris, 2013). The sad irony is that one does not need to look far to find a water-cleaning device, particularly in India, where cheap manufacturing abounds. With a plethora of water cleaning options available, why are so many people still lacking access to clean water?

As with other challenges in India, the answer is complex, and it often relates back to the enormous size of the population, 73% of which live in rural areas (Government of India, 2011). One simplified answer is that the fit, scale, and sustainability of the solutions are often insufficient to meet the needs of the millions of people lacking access to clean water. Too often the solutions presented fail to examine the problem from a systems perspective. As such, they are inherently unsustainable and, thus, unable to fully tackle this chronic issue.

Lessons from Technology-Driven Solutions Designed for Developing Economy Use

"Experiences with miracle cures and quick fixes can teach us much about both the power and the limits of top-down innovation, as well as about the resistances to them. They don't often leave much behind in terms of changes to quality, opportunity or system change."
- Alexandra Draxler (Draxler, 2014)

There is much to learn from products that have been designed for use in the Global South to varying degrees of success and criticism. The following two examples of socially-motivated products have

two different foci: children's education and clean water. Both provide important insights into what happens what technology drives 'innovation' and operates outside of a systems design approach.

One Laptop per Child: Top Down Innovation

Since its launch in 2006, the One Laptop per Child project has been a lightening rod for both praise and reproach as a humanitarian design initiative. The brainchild of Nicholas Negroponte who founded and is the chairman of the One Laptop per Child (OLPC) non-profit organization, the OLPC has a mission to "empower the world's poorest children through education" (One Laptop per Child, 2016). The goal has been to get its sturdy, easy to use, self-powered laptop into the hands as many children as possible. Through various design iterations and funding approaches, the OLPC has hit several road bumps along the way. The reasons for this, as many critics point out, are due to the initiative's overall philosophy on the role of technology in education (Watters, 2012).

At the heart of the OLPC is the belief that technology, in this case, the laptop itself, is the catalyst for children's self-learning: by accessing information that would otherwise be inaccessible to children due to their socio-economics circumstances related to their schools, homes, and communities, the technology will broaden opportunities. Many critics who work at the intersection of ICT and educational pedagogy have been clear and severe in their criticism for the program. Alexandra Draxler, a consultant working in this realm, states, "The arrogance and ignorance of the assumption that the presence of laptops would instantly transform young children into autonomous, disciplined seekers of knowledge and understanding was always evident. It was tragicomically epitomized when Nicolas Negroponte famously said that he would favor flying over poor areas and throwing the tablets out of helicopters" (2014).

Others have been steadfast in the support for OPLC. Recognizing that the initiative fell short in terms of distribution and implementation, those on the side of technology as a catalyst for change feel more programs like this are needed. Sandra Thaxter, who works with youth in Africa to bridge the digital divide as Executive Director of the organization, Small Solutions Big Ideas, states, "One Laptop Per Child initiated an intervention into countries where there are more children than existing national governments' education efforts could possibly be effective…"It is about disruptive, creative, child centered learning"…"We need more One Laptop Per Child movements…" (2014).

Before the OLPC arrived on the scene, other initiatives, including government-sponsored programs had been implemented and subsequently studied to understand the effectiveness of programs aimed to bring computers into schools and homes of less advantaged students. The results have pointed to the lack of evidence that the presence of technology increases test scores and other learning indicators. A study of an Israeli government sponsored lottery program aimed at bringing computers into elementary and middle schools showed little positive impact and actual negative consequences. There was a consistently negative and marginally significant correlation between computer-aided programming and math and language test scores observed at various grade levels (Angrist & Lavy, 2002).

A study of a state sponsored voucher program that sought to bring more computers into the homes of children in Romania found an actual decline in academic achievement. The study's authors conclude, "We find that despite efforts by the Romanian Ministry of Education to encourage the use of these computers for educational purposes, relatively few children had educational software installed on their computer, and fewer still reported using their computer for educational purposes. Instead, computers were mainly used to play games. There is also some suggestive evidence that children who received vouchers spent less time reading and doing homework" (Malamud & Pop-Eleches, 2011). This study showed that there were several other key factors at play in the

introduction of this technology, such as parental involvement and rules around the use of the computer as well as availability of appropriate software to support learning and the ability to use the software as intended.

What have been most condemning for the OLPC's overall approach were the evaluations of the organization's impact in countries where its laptops have been introduced. In Peru, the Inter-American Development Bank conducted a study using data collected after 15 months of implementation of the OLPC program in 319 rural primary schools. While the results showed a dramatic increase in the access to computers overall, the impact on actual learning metrics was less impressive. There was no evidence of a positive effect on math or language test scores, though the researchers found that there was no software or applications on the laptops that would have directly supported learning in these subject areas. The OLPC roll out in Peru seems to have little discernable impact on student attendance rates, homework time allocation, or overall motivation for learning. Reading habits were also not influenced, which is "perhaps surprising given that the program substantially affected the availability of books to students. The laptops came loaded with 200 books, and only 26 percent of students in the control group had more than five books in their homes" (Cristia, Ibarrarán, Cueto, Santiago, & Severín, 2012).

These studies have shown that the cost of implementing technology often comes with a reduction in expenditures desperately needed elsewhere within the educational environment that can have more profound impacts. For example, in the Peru study, researchers concluded that "in poor countries where teachers' salaries are low, the opportunity costs of implementing (capital-intensive) technology programs may be substantial compared with alternative labor-intensive education interventions including reductions in class size and professional development" (Cristia, Ibarrarán, Cueto, Santiago, & Severín, 2012). It was the same thesis in the study on Israeli's computer lottery program that showed spending in other areas could be more advantageous. As the study's authors discuss, "A possible explanation for our findings is that CAI [computer aided instruction] is no better and may even be less effective than other teaching methods. Alternately, CAI may have consumed school resources or displaced educational activities which, had they been maintained, would have prevented a decline in achievement" (Angrist & Lavy, 2002).

What these studies point to is that technology, in isolation, cannot educate students. It is not a silver bullet, which alone will allow children to overcome the challenges and limitations of their schools, homes, or broader socioeconomic circumstances (Watters, 2012). Technology, and, in the case of a laptop, no matter has smartly and intentionally designed, is a specific tool that works as part of a larger system that includes parents, teachers, curriculum, school boards, electrical and other infrastructure, local customs, and broader societal norms. By ignoring these interconnected factors or thinking that the intended technology in and of itself can transcend them is futile and has been, through qualitative and quantitative analysis, proven repeatedly to be ineffective and potentially detrimental.

LifeStraw: Technology Operating in Isolation

Another product that has been touted as both an example of forward-thinking by some (Wolfson, 2015) and short-sighted and self-serving (Starre, 2012) by others is the LifeStraw. The LifeStraw, family of products developed by Swedish company, Vestergaard-Frandsen, uses patented technology to provide clean drinking water. This solution has been used globally but particularly in areas of Africa where in 2011 the company rolled out a free distribution of the Lifestraw Family product in rural Kenya to 877,500 households (Murphy, 2013).

There has been significant criticism of the company's approach. Philanthropist and founder of the Mulango Foundation, Kevin Starr, has been a vocal opponent of Vestergaard. In a series of articles in the *Standford Social Innovation Review*, he finds fault with the product's poor design, the cost of filters, and the overall business model which financed the free distribution of LifeStraw through a use of carbon credit offsets (Starr, 2011 & 2012). Starr visited the communities where Vestergaard had given out its filtration units for free and found that in most households, the LifeStraw sat unused or in disrepair with no means for replacement (Murphy, 2013).

Other criticism for these products has been that this approach ignores the fact that in most areas where LifeStraw has been distributed, water still needs to be collected, often from sources that are far distances from the home (BBC News, 2006). Paul Hetherington, a spokesperson for WaterAid, believes that the establishment of a reliable source of clean water and education on good hygiene is a viable solution to tackle challenges with water supply and to significantly reduce the risk of disease. (Hult Social Entrepreneurship, 2013). Critics have argued that a solution, which works in conjunction with infrastructural projects, would have broader impact. However, this approach does not fit with the history of Vestergaard's business model, which focuses on product-driven solutions. A revenue stream for the company has come from selling blankets and textiles to African governments and aid organizations for use in refugee camps and other emergencies (Wolfson, 2015).

Inherit in Vestergaard's approach is the idea that technology will solve the problem. However, a series of studies in various parts of Africa on the use of the LifeStraw in rural villages (Boisson, Schmidt, Berhanu, Gezahegn, & Clasen, 2009) and settlement camps (Elsanousi et al., 2009) have shown mixed results, questioning the effectiveness of the technology itself. Even if the technology at the heart of LifeStraw is 99.99% effective, as Vestergaard states in its marketing of the LifeStraw products (Vestergaard, 2016), the criticism around its pricing, distribution, profit-driven model, and lack of infrastructure consideration points to the absence of systems design thinking.

LifeStraw Personal and LifeStraw Family are not part of a plan that carefully considers the long-term sustainability of these solutions. As Starr points out, the roll out of the product in Kenya cost Vestergaard $30 million, the sum raised from carbon credit sales. To be sustainable, another $30 million would be needed every three years to replace the original units (Starr, 2011). There is no system in place to provide maintenance nor to offer the option of buying new units as needed. Thus, the possibility of long-term adoption of this solution is highly limited.

Based on this model, it is difficult to discern the long-term economic impact for the local communities where the LifeStraw product was given out. LifeStraw is made in China, where production costs are lower (BBC News, 2006). While temporary employees were hired to distribute LifeStraw during this distribution program, there was no significant long-term investment that could create jobs or educational opportunities around the product.

According to a 2014 report issued by Vestergaard, due to lack of program funding for its massive distribution initiative in Kenya, in the latter phases of the project the company relied on volunteers to provide on-site training, education and follow-up. "Volunteers were paid a nominal daily rate and provided a stipend for transportation costs. A total of 478,609 households were visited over this period by 1,374 volunteers" (Vestergaard, 2014). With $30 million raised by Vestergaard through the sale of carbon credits on the European market (Wolfson, 2015), the program relied on local volunteers in a country with an average GNI per capita in 2015 of $1,340 (The World Bank, 2015).

The parallels between the OPLC and the LifeStraw products are many but can be distilled into one important lesson -- both rely on the technology as means to an end. There was minimal interaction and consultation with key stakeholders in the development and implementation of both of these projects. The results are that these products fail to properly address and solve systemic issues at

the root of the challenges they aim to solve. By ignoring or overlooking these entrenched obstacles, or thinking that technology could overcome them is the Achilles heel of these proposed solutions. Whether due to naiveté or hubris, laziness or profit motivation, this lack of system thinking as a foundation for the design and implementation of these products on the ground doomed these projects from the outset. While both projects carry on, have strong proponents, and, in the case of Vestergaard, continue to make profit, the intended impact is fractional compared to what is could be if these products had been created as intricate parts of a comprehensive, smart, and fully engaged and informed systems design.

The Need for Other Models

These products point to the need to look to beyond technology to develop more robust, holistic solutions. Products like the One Laptop per Child, LifeStraw, and others created for use in the Global South have pushed innovation and developed technologies with the intention to help others. There is no doubt that such initiatives help to bring learning opportunities and clean water, respectively, to people who can benefit. However, when it comes to long-term adoption and the overall improvement of chronic issues, these solutions fall far short. When a product is 'dropped' into a community without first developing some sort of infrastructure or an eco-system around it, it will quickly become obsolete and is doomed to fail. With no local knowledge or financial mechanism in place, with no understanding of local customs, social dynamics or political implications, with no real educational engagement or community outreach, there is no system to support the product's long-term use, and, thus, its potential long-term, sustainable benefit.

So what is the answer? The answer lies in a systems-driven solution - one that closely considers the environmental, cultural, social, and financial impacts and has the best chance for making measurable change over the long term. A product designed hand in hand with those it is intended to benefit and reflects unique and very specific strengths and challenges at a local, community level, has a better chance for broader adoption and impact.

This is the impetus behind the CleanCube Project, to develop a low cost, low-tech solution that brings clean water to communities that need it. Currently in the testing stage, the CleanCube product is a dissolvable cube made of natural plant-based material that can be added to stored drinking water to kill 100% of E. coli bacteria (CleanCube, 2016). However, the solution is not just the object itself; it is the process by which it is derived and the system in which the object exists. The participatory design process and development of a business model that directly engages women in the economic life of the product are key. So is creating an ecosystem around the solution that, is self-sustaining, and is able to be replicated and scaled. The end goal is to maximize the design solution's reach and impact over the long term.

CleanCube Project Background

In 2014, the CleanCube Project and the Principal Investigator, Sarah Tranum, received research funding from Grand Challenges Canada's Stars in Global Health program. Grand Challenges Canada is dedicated to supporting Bold Ideas with Big Impact® in global health (Grand Challenges Canada, 2016). Funded by the Government of Canada, Grand Challenges Canada focuses on funding social enterprises that offer innovative solutions to some of the most challenging global issues. This proof of concept funding has made field-based testing of CleanCube possible.

The pilot community, called Zuarinagar, is located in South Goa not far from the State's Dabolim Airport. Zuarinagar is a semi-legal residential slum that built up around the industrial area attached

to a large agriculture chemical plant. The majority of the residents living here are migrants who came looking for work, travelling from the farms and villages located in the neighbouring state of Karnataka. Most households have one or more family members who work in some capacity for the main factory or the surrounding auxiliary businesses and services.

During the first phase of this project, significant time and effort were invested to build relationships with Zuarinagar's community leaders. Working in conjunction with a local doctor, free weekly health clinics focused on women and children helped to build trust and rapport with women in the community. Making the connection early on between water, health, sanitation and hygiene has been a critical cornerstone of the CleanCube project and the community's buy-in and participation in the project.

An initial survey of 33 households provided significant data about water usage, water cleaning and storage practices, health and hygiene, and economic livelihood. The focus of the survey was women and learning about their relationship with water and the intersection with the health and wealth in their homes. In this community, household taps deliver water but for only part of the day. All residents reported that there are several hours in a 24-hour period, or sometimes days in row, during which no running water is available and, thus, reliance on stored water is crucial. Households use a combination of large plastic barrels, steel urns, and plastic bottles to store water. The collection, storage, and usage of the water are consistently the responsibility of the women living in the house, often falling on the shoulders of the youngest daughter or daughter-in-law.

One of the key insights gleaned from these surveys was the cleaning methods used and its correlation with household illness. Only a few women reported boiling their drinking water or using a commercial filter device. However, those who did use these methods reported fewer incidents of illness in the home. In comparison, the majority of those surveyed reported higher incidences of cold and flu like symptoms, skin infections, and stomach pains among adults, but especially in children. These symptoms correlate with those caused by ingesting water, which contains bacteria like E. coli.

Over 90% of women reported having no indoor bathrooms, explaining that their toileting facilities are located in an open field located between the outskirts of the slum residences and the nearby highway. All respondents reported dumping their household garbage in an open area that are also located in the vicinity of the open toilets. Other community members, who were not surveyed, explained that these practices are particularly problematic in the rainy season when runoff carrying garbage plugs the ditches located within the community and brings trash as well as human and animal waste in and around homes.

CleanCube Product: One Part of a Comprehensive System

This work in the community reinforced the need to look to low-tech, intuitive methods of cleaning water. Furthermore, it focused the research on solutions applied to stored drinking water. By understanding the daily reality of water in the homes, it made it immediately clear why several existing water-cleaning devices on the market are inappropriate or just not useful in the context of homes where water from the tap is unreliable and irregular.

Plants, particularly those that are widely available and familiar to the average Indian household became the focus of the CleanCube Project's research. Recently published studies from leading research institutions, as well as ancient Vedic texts that are at the core of Hindu traditions, identified a number of plants for their abilities to eliminate bacteria in water. Building on this research, the CleanCube team began further testing. Working with India-based microbiologists, two native plants, used traditionally in Hindi ritual and throughout Indian culture, have been the focus

of a series of experiments. The results have shown great promise and rigorous lab-based testing and evaluation continues. By building from the body of existing research on traditional Indian plants and their antimicrobial properties, the CleanCube project added a layer of rigour to the research and viability in terms of real word application. Bridging lab testing with hands on work in the community makes the CleanCube Project unique, innovative, and positioned to significantly further the understanding and potential use of theses plants for cleaning water in a household setting, particularly in slum and rural areas of India where it is needed most.

Currently, funding is being sought to support the continued testing that will allow the team to determine the minimum amount of plant material required over shortest time frame necessary to eliminate bacteria in water. The next critical steps are then determining the best methods of employing this basic technology is a way that is intuitive, 100% effective with everyday use, and feasibility for production. Whether using loose powder measured with a spoon or powder compressed into a pre-measured dissolvable cube, the outcome will reflect research that has been verified and methods that have been tested in the field in homes of CleanCube's intended users.

Creating Local Economic Impact: Small Batch Production Model

The goal for CleanCube is to develop the local infrastructure to create small manufacturing hubs to produce and distribute CleanCube units. On-going work in the community created the foundation for testing CleanCube's small batch production model. Lessons learned from successful India-based models like Lijjat Papad, an ISO 9000 cooperative company with 43,000 women members (WIPO, 2014), and Self Help Groups, designed to help small groups of women collectively save and engage in training and income generation activities, were invaluable. CleanCube has gleaned best practices from these to build a robust, sustainable model for the production of its water-cleaning product. The CleanCube model trains women to work near their homes, allowing them to fit these activities around their daily household responsibilities.

Through a trial period, CleanCube worked with two groups to produce prototype units. Women were given an orientation and training to educate them about the importance of clean water, hygiene, and health, as well as the production process, the concept of quality control and the importance of working together as a group. After hands on training and guidance for the first few days, the groups were in full production mode. The women found ways to improve and perfect each part of production. They were strongly encouraged to share their insights and feedback to better inform the process.

The women met their production goals and adhered to high quality standards. They earned enough to supplement their household income by 30-50%. Production pay was set to provide a living wage while also allowing the retail price of the CleanCube product to remain highly afforable at 1 Indian Rupee per 1 Litre of clean water. Based on this model, one CleanCube unit able to clean a week's supply of clean water for an average household costs Rs. 50 or the equivalent of less than $1.

The women who participated came from different cultural, religious, political, and educational backgrounds; most had never worked outside the home. They worked together towards a common goal. Through the process they exceeded their expectations, saw their status in their own homes raised, and recognized the potential for change and new opportunity in their lives. Working within very close proximity, women can work around their daily schedules to take on this flexible work and have earnings which can significantly contribute to the household. This model offers women both economic and potential social empowerment opportunities but does not outwardly disrupt the cultural dynamics of the home and community.

Connecting Daily Habits with the Sacredness of Water

One of the concepts the CleanCube team had been working on was how to tie the inherit sacredness of water that is prevalent in Indian culture with the need to protect and clean the water that people drink in their daily lives. Ganga is a powerful goddess in the Hindu tradition representing the mighty Ganges River that connects the Himalayas to the sea and along the way provides life to all those dependent on her waters (Doron, Barz, & Nelson, 2013). Every three years, a months long pilgrimage, called the Kumbh Mela, take places along the banks of the Ganges bringing tens of millions of Hindus to worship, swim, and drink its waters. This is said to cleanse the pilgrims' sins away (Kumbh Mela, 2013). This ability for water to cleanse a person is also present in Christian, Jewish, and Islamic traditions. It became clear that if the CleanCube Project could make clear the connection between the need for clean water in modern daily life and the sacredness of water in faith and ritual it would be a powerful way to reach a broad range of people, to change attitudes, and promote lifesaving behaviours.

The CleanCube team worked to develop a broader approach to telling this story. In the team's research, the Hindi god Varuna, the god of the celestial seas, was re-discovered. Varuna is a god who was once powerful but has lost his popularity over the millennia to the goddess Ganga (Sreenivasarao, 2012). Ganga's connection with the Ganges River and with the powerful god, Shiva, made her more heavily worshipped and associated with water. The lesser-known Varuna is not only the god of the seas but is also said to rule cosmic order. When things become imbalanced in the world, it is said that Varuna wields his power to rebalance the order, using the power of water to realign things that have gone awry. The serpent in the form of a noose that Varuna holds in his hand carries the power to cause heavy rains, floods, and tsunamis. Scholars have drawn parallels between a story involving Varuna and a worldwide flood with the Christian story of Noah and the ark (Sreenivasarao, 2012).

Varuna'a story seems more topical now than ever before, as India recently experienced record-breaking and deadly high temperatures, droughts and floods, widely attributed to a climate that is changing and considered out of balance (Bhatia & Riley, 2016). The CleanCube team considered ways to revive Varuna to bring him back into a place of conscientiousness with the average Indian in order to communicate the importance of balance in nature and of the need for respecting and cleaning water. From this work, the team set out a set of interconnected design interventions as the model to connect daily water practices with sacred traditions. One was the creation of a large-scale community education event and the other was a kit that could be used as a part of CleanCube Ambassador Program (explained below) to educate and promote the CleanCube product in women's homes. The goal of the community event was to be an effective guerrilla marketing initiative that entertained, educated, and promoted the CleanCube brand. The kit and CleanCube ambassador model was to be a powerful pathway to teach women about the need for clean water, good sanitation practices, and how to use the CleanCube product safely and effectively.

Powerful Messaging: Community-Based Education Events

A key aspect of the CleanCube overall systems approach solution is community-based education. For a product to be effective, people must first understand the need for clean drinking water. Explaining the science of bacteria and connection to illness is one approach, but it also became clear that connecting to something more familiar was much more powerful.

The CleanCube Project team worked collaboratively to develop a community event built around an original story featuring Varuna. The story is based on following five young girls while they walked from their homes carrying water vessels to the communal water tap in order to gather water for

their homes. Along the way they engage in various activities that emphasize the need for greater education around and respect for clean water. Varuna appears to the girls and helps them understand the need to care for water and to take care of their health through good hygiene practices. Varuna explains that the water that is in their storage containers is the same sacred of water that runs through the Ganges and that gives lives to all beings.

The story line was illustrated using images from the Zuarinagar community and was narrated in Hindi. Interwoven into the story were live acts. An empty lot in front of the local primary school within the Zuarinagar community was transformed into a temporary outdoor event space. A stage, lights, and sound were set up and the illustrated story was projected onto a backdrop. It was narrated and incorporated live acts. A local magician and Indian classical dance troupe presented water-related performances that were integrated into the broader story. The magician created a show around water tricks and the dance troupe of young dancers created an original dance piece about the need to care for nature and to respect water by keeping it clean.

With over 300 hundred people in attendance, this free community event proved to be a powerful medium for educating and promoting behaviours and activities that could make the community healthier. Implemented on very a reasonable budget, this event was designed to be easily replicated and used in each community where the CleanCube Project expands its reach. Compared to a traditional media campaign, which would be far more expensive and less likely to reach people of one specific targeted community, this type of community event is far more effective. It creates a buzz; it opens people's minds, because it is so new and unfamiliar, particularly in poor community, and because it creates joy and memories.

Developing an Innovative Marketing and Distribution Model: Door-to-Door Ambassador Kit

This story is also the foundation for the CleanCube Ambassador Kit. This Kit is used by CleanCube Ambassadors, who are female members of the communities where CleanCube has a presence, to go door-to-door to speak to small groups of women in their homes. The story of Varuna is used to connect to daily water habits, but it is geared specifically towards women.

As an emerging economy, India has a fascinating mix of outreach and marketing methods. A far-reaching, subsidized satellite TV network coupled with a sophisticated advertising industry brings thousands of Bollywood celebrity-endorsed products into the homes of even the poorest Indian households every day (Kumar, 2008). The multi-billion dollar advertising industry is juxtaposed with the existence of more traditional methods of marketing, such as hand-painted murals located within communities on the sides of homes and stores.

The team's survey of the broad-ranging methods used for marketing to the vast and diverse population of India offers insights, both in terms of challenges and opportunities, for reaching the intended beneficiaries of CleanCube. Unable to compete financially in the TV commercial realm and understanding the limitations of more primitive means of advertising, CleanCube team foused on a different marketing method for the CleanCube project. Gleaning from the tried and true models in the North American context of Avon, Mary Kay, and Tupperware brands (Direct Sales Aid, 2016) that were built on the strength of women ambassadors and their ability to connect with fellow women, the team worked to develop and test revised and updated models that can work within the Indian context.

The research conducted in the pilot community showed the strength of interpersonal relationships between women and the power they hold to promote and share important, information about health, sanitation, and hygiene in the home. The project's work with a community-based doctor within the context of free health clinics underscored how effective direct contact is to dispersing

pertinent health information and shifting attitudes and behaviours. The work with both production groups reinforced the power of women to share and learn from each other.

The CleanCube Ambassador Kit, given to each CleanCube Ambassador, includes a laminated flipchart that serves as a visual guide to the Ambassadors' discussion with the group of women. These visuals allow the content to be understandable regardless of language spoken. The Kit connects daily water usage to the sacred traditions; it underscores the importance of clean water and the diseases that can result from drinking unclean water. The Kit demonstrates safe water handling practices including how to use the CleanCube product to clean the water from bacteria.

The Kit makes is easy for a women regardless of her education level to be able to explain the basic science behind bacteria and water-borne diseases. This allows a range of dedicated local women to serve as CleanCube Ambassadors. The Ambassadors sell the CleanCube product in conjunction with distribution through local stores and kiosks in the community.

The Kit also contains a children's book, which includes pages that can be coloured, given to the children in the home. The story of the children's book is a condensed version of the community event and reinforces the ideas expressed about the sacredness of water and the connection with daily water habits. Varuna and the five female child characters are the main focus of the story; the background illustrations resemble the realities of the communities in which the CleanCube Ambassador is living and visiting.

Small, Beautiful, Scalable, and Profitable

The CleanCube Project's small, interconnected systems approach pulls inspiration from the work of E. F. Schumacher in his book *Small is Beautiful* and from the microfinance movement championed by the Nobel Peace Prize Laureate, Muhammad Yunus. Schumacher's call for economic systems that are smaller and more local (Schumacher, 1973), and Yunus's work to put small amounts of capital into the hands of the world's poorest challenges the conventional notions of efficiency and effectiveness (Yunus, 1999).

Building solutions and economic mechanisms that are at a human scale offer an alternative to the current globalization-driven capitalist model – where bigger stores and more cost efficient supply chains means bigger profits and market share. However, in the business of bringing clean water to those with the least amount of pocket change, local, self- sustainable, and scalable solutions are the answer. There is a need for a different model - for businesses, NGOs, and charities - one that is financially viable and efficient but where success is also defined by local impact and long-term change.

The CleanCube Project encompasses the broadest definition of sustainability. CleanCube's use of plant-based, natural materials make it a wholly environmentally conscientious product. Yet it does not just focus on an environmentally sustainable way to clean water; it also creates a means for people to continue to have access to the solution over time. Establishing a local business model helps to develop financial sustainability and non-reliance on outside funding and expertise to continue. This model builds a structure for on-going distribution and accessible pricing. The focus on women's empowerment, while including input and buy-in from both male and female members of the community, is critical pieces to the social sustainability of the model. The participatory design process gleans local knowledge and is shaped by the daily practices of women in the community to ensure that the solution is culturally sustainable. It is this well-rounded, holistic approach to sustainability that is lacking in most solutions designed for the Global South.

No one-size-fits-all solutions exist. The pull to respond to global issues with a broad brush is reactionary, a waste of resources, and can do more harm in local communities than good, no matter how well intentioned the action. While there has been benefit from the One Laptop per Child initiative and the LifeStraw line of products, there is much opportunity to develop smarter, more interconnected solutions. The time has passed for top down approaches that operate in separation and ignorance of the broader systemic issues and do nothing to engage in change at this level. Instead, what *is* needed are models that build upon insights from the community and seek to empower women as income generators and decision makers. Solutions rooted in systems design can be adapted and replicated, and such solutions can potentially reach millions of people.

One goal of the CleanCube Project is to demonstrate that this model is an effective solution not just to water issues but also to other difficult problems. Design practitioners taking on other complex global challenges have the opportunity to apply a similar holistic approach to co-designing sustainable solutions. Working in local communities sharing and gleaning knowledge, building capacity, and planting the seeds for an effective, scalable product requires an investment of time and resources but yields the most potential for real, sustainable solutions. The development of an effective product or technology that will improve a chronic problem is essential. Looking beyond the product itself to design the entire ecosystem around the solution is what creates the potential for momentous change. This type of approach makes way for powerful design interventions that can overcome barriers of distribution, financing, and cultural adoption to reach scale in other communities and around other challenges across India and in other parts of the world.

Conclusion: The Systems Must Be Localized

The goal of the CleanCube Project – to develop a product that provides clean water that can be manufactured locally and made widely accessible through broad market distribution and affordable pricing - is being reached. Lab testing, small batch production, community education, and innovative marketing and distribution models have been tested, and the results underscore the potential of this social enterprise model to impact positive, long-term change in the communities where CleanCube is launched. The last 22 months of research have shown that this model can provide clean water affordably and accessibly, can create measurable economic impact, can educate and change behaviours about sanitation and water health, and can catalyse significant empowerment opportunities for women and their families.

An important take away from the CleanCube Project as a case study for systems design approaches to tackling access to clean water, is the focus on a system that is comprehensive but is also very localized. It is this focus on community level challenges and the ability to adapt and flex as needed that can allow it to be replicated and scaled to reach the vast population that can benefit from clean affordable source of drinking water that the CleanCube model can provide. On the other hand, the examples presented above -- One Laptop per Child and LifeStraw -- are generic solutions in both design and implementation that cannot be tweaked or customized to better reflect the needs and challenges of a local community of intended users. A product built within a comprehensive system and interconnected with broader issues around education, economics, politics, infrastructure, social and cultural contexts, can address local needs while being able to reach millions of users.

The 2016 RSD5 Symposium in Toronto had an underlying theme that resonated for this author: the contrast of macro- and micro- scales in system design thinking. On the first day of the Symposium, the walls were filled with metadata posters communicating complex sets of data. They were beautiful in both the visual design and in the story and implications of the data being presented; however, it was sometimes difficult to find the individual user in these vast information landscapes.

This disconnect to distinct users was further reinforced in the presentations of various researchers and practitioners who were using high level sets of data. The user that this data was intended to represent and positively impact though better analysis and interpretation of key statistics and qualitative information was too small to be seen in the system of icons that represented much bigger players - too ensconced in big data to have her discrete story heard.

These observations were juxtaposed to the presentation of those whose work encompasses systems level thinking but also keeps the user front and centre. One example is Liz Sanders and her work using basic but smartly designed participatory tools to allow users to meaningful engage in solution finding through play, expression, and deep application of their individual expertise (Sanders, 2016). The need to connect at a deeper personal level within our designed systems resonated in comments by Paul Pangaro when he expressed the need for conversation platforms that went "beyond the superficial" (Pangaro. 2016). In Erik Stolterman's keynote presentation, "The Interactivity Field and Systems", the speaker hinted at the need for smarter, localized systems. If and when those interfaces that are generalized and indistinct (i.e. automatic door opening sensors opening unnecessarily opening doors as someone passes by a store) become too numerous and overlapping, they will be successful in creating noise and chaos instead of an individualized, augmented experience as intended (Stolterman, 2016).

These examples, which span both the physical and digital realms, reinforce the need to utilize the many tools available to the current generation of systems designers. The ability to obtain and wrangle massive data sets and distil them into meaningful insights is a tremendous opportunity. The capacity to create robust products and services within holistic systems that reflect individuals at a community level, wherever and however that community is defined, is desperately needed. The combination of both global and local thinking is where the power lies, and moving forward in this vein reflects lessons learned from those past interventions that have been top down, technology driven, and which have left a wake of problems yet to be fully addressed. This is only way forward as systems thinkers, innovators, and do-ers intent on making meaningful in-roads to solving some of the toughest challenges faced collectively as a society.

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