Dispatches from the field: reflections and experiences on the use of Foldscope in Project SHINE in the Ngorongoro Conservation Area, Tanzania

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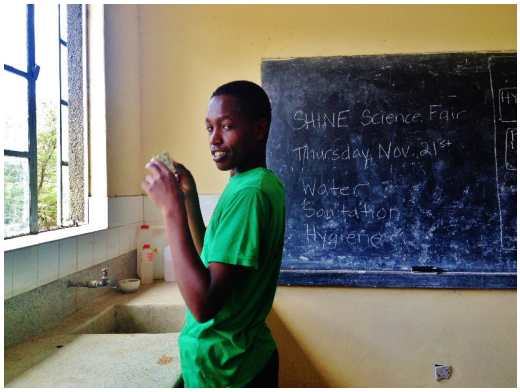
In 2014, funds to pilot Project SHINE (Sanitation and Hygiene INnovation in Education) were received through a Stars in Global Health grant from Grand Challenges Canada, which is funded by the Government of Canada and is dedicated to supporting bold ideas with big impact in global health. The essence of the SHINE approach is to facilitate and inspire the development of innovative, youth-driven strategies to improve sanitation and hygiene among Maasai communities in the Ngorongoro Conservation Area, in rural Tanzania. In particular, the SHINE approach aims to achieve a multiplier effect with respect to improvements in education, health and livelihoods among youth and communities.

Innovation is a key component of the SHINE approach and in that respect, the Prakash Lab and the frugal innovations they have been developing, in particular Foldscope, have to a large extent put the 'I' for INnovation in SHINE. **Unlocking, unleashing and igniting the curiosity of youth and harnessing that energy to develop innovations that improve health, education and livelihoods hinges on providing them with the necessary tools and platform.** As part of the SHINE intervention, secondary school students in the Ngorongoro had the opportunity to use the Foldscope to engage in hands-on, curiosity-driven science – an entirely new experience for them, given that experiential learning and participatory science are not well incorporated in the curriculum. In SHINE, we aimed to address this gap through the development of innovative and participatory curricula which were carefully aligned with the national level objectives for science.

Through the engagement of Dr. Manu Prakash and his team, in particular Dr. Jim Cybulski and graduate student Elizabeth Marshman, students and teachers in the Ngorongoro were provided with the tools and the platform described above that are so essential to fostering innovation and nurturing the development of young scientists, who will go on to be the educators and leaders of tomorrow.

The students, and many of the teachers in the Ngorongoro had not seen or touched a microscope previously. Being handed a Foldscope seemed to be both a terrifying and empowering experience for them. As Jim stood in front of the class instructing wide-eyed students on how to assemble a Foldscope, we observed initial trepidation and concern that they might damage the paper as they punched out the various parts. This dissipated rather quickly however, and students rapidly assembled Foldscope, casting aside the instructions (which by the way, have now been translated into Swahili, the national language of Tanzania). Soon, **a peer to peer teaching model emerged** as a few leaders who caught on to

the process particularly quickly, assisted their neighbors and others in the classroom without prompting. Teachers and adults took much longer to assemble their Foldscope and tended to want to consult the instructions rather than experiment or go with their intuition. It has been said that curiosity resides in children to a much larger extent given that they are unencumbered by preconceptions and assumptions about what works and what doesn't; therein lies the core of the SHINE approach, which aims to tap into and harness the curiosity and potential of youth as innovators with the capacity to develop strategies to improve the wellbeing of their communities.



During the sanitation science fair, which was the first ever to be held in the world to the best of our knowledge, students used the Foldscope to perform investigations that related to questions they had concerning sanitation and hygiene. For instance, students examined the feces of dog, sheep and cattle for the presence of parasites. This very culturally relevant question for pastoralists emerged from the students themselves during group discussions we held with them prior to the roll out of SHINE. By putting Foldscope into the hands of these youth, they were empowered to investigate this question themselves, rather than simply reading from a text book or being told by a teacher or outsider. We wish that we had attached iPhones or cameras to the Foldscopes so that we could share more results with you, but that will have to wait until the next sanitation science fair! There are a host of other sanitation and hygiene-related lessons and experiments that would be relevant to explore through the use of Foldscope, such as the effectiveness of handwashing with soap. Some of these ideas are currently being developed by Dr. Prakash and others, which we hope to test in the field and incorporate in the SHINE curriculum. Do you have an idea of a sanitation or hygiene related experiment that involves Foldscope? We would love to hear from you!

Foldscope is undoubtedly one of the most impactful frugal tools of our time and it **left an indelible impression on the youth of the Ngorongoro Conservation Area**. Students were so inspired by the frugal tool, that they wrote song about Foldscope and what it meant to them, which can be viewed here: https://vimeo.com/137421188

In discussions with students, they told us that they want to start small Foldscope businesses so that they can share the tool with the rest of their community and across Tanzania. A particularly poignant quote by one female student just prior to the graduation ceremony illustrates how impactful exposure to Foldscope has been for these students. She remarked that she aspires to be '*the next famous scientist to make an idea, a project just like the Foldscope that can help my community to be healthy'.* An important point to emphasize here in relation to this, is that Foldscope is as much about process of empowerment, engagement, inspiration and igniting curiosity, as it is about product. These students would not otherwise have had the tools or opportunity to pose microscopy-related questions and be able to answer them. Being shown a concrete example of frugal

innovation which demonstrates the possibility of developing an innovation oneself in the context of resource scarcity is tremendously powerful and an integral part of that process.

Demonstrating the impact of any innovation is a well-recognized challenge, particularly when it involves capacity building which requires long-term investment and sensitive metrics to measure impact. In Project SHINE we measured baseline and follow-up science interest and motivation, among other behavioral aspects such as knowledge, attitudes and practices related to sanitation and hygiene. However, social desirability bias, ceiling effects, and gamma change among other issues can influence the findings of studies. We used triangulation of methods as a strategy to overcome the challenge of demonstrating impact in Project SHINE; rather than relying on quantitative data alone, we used a range of methods to assess the impact of the intervention throughout the various phases of the project. For instance, we used digital stories, in-depth interviews with teachers and group discussions with students and other community stakeholders to develop an understanding of their experiences and perceptions of the project and its impact. As a community of Foldscopers, we need to think carefully, creatively and systematically about how we document and demonstrate the impact of this frugal tool on society.

So what happens if one of the missions of the Prakash Lab, to democratize science education and put a Foldscope in the back pocket of every child on the planet, is achieved? Will youth and communities be empowered to make transformative improvements in the education, health and livelihood prospects at the local level? Will we as a global community be better equipped to solve some of the most pressing sustainable development challenges of our time? Of this I have no doubt. But in addition to the question of demonstrating impact discussed above, it begs the question of how scale up and spark a diffusion of innovations so that these tools are accessible to the masses. The commitment demonstrated by the Prakash Lab to engaging the global Foldscope community through the Microcosmos website is a promising way to begin to connect people with a shared interest and passion in microscopy, but also those interested in innovative science education, global health and sustainable development. Fostering these transdisciplinary connections is essential given that the intractable challenges we face today cannot be solved by traditional siloed approaches. In the not-so-distant future, Foldscope hubs and clubs, centers of frugal innovation or other forms of organization are likely to emerge as word gets out and people begin to grasp what a game changer Foldscope is. I am honored to be a part of the Foldscope movement in some small way and to be among those working to explore the potential of Foldscope for linking innovative science education and global health for sustainable development, in Tanzania and beyond.

If you are interested in reading about Project SHINE's conceptual framework and study design or the formative research, please contact me and I will send the papers, you can also follow Project SHINE updates here: https://www.facebook.com/projectshineedu/. I am looking for frugal science curriculum developers and other passionate team members so feel free to get in touch with me at

sheri.lee.bastien@nmbu.no or sbastien@ucalgary.no. Warm thanks and gratitude to the Prakash lab for their continued support and engagement on the project, we look forward to future collaboration with you and the rest of the Foldscope community!