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Drowning prevention by design: the semiotics of prototyping in low-resource environments – case study Zanzibar

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Abstract: This paper presents an overview of an exploratory case study collaboration between Arts University Bournemouth (AUB) and the Royal National Lifeboat Institution (RNLI) in support of an RNLI delivery programme for international community management of drowning prevention in low-resource environments. The study focuses on the development of low-volume public rescue throw-lines that can be community made and maintained, the assembly and use of which are supported by a set of RNLI-developed instruction manuals intended for universal dissemination. The study examines the clarity of the instructions in the context of the makers' interpretation of the manuals within the local constraints of Zanzibar. Preliminary findings indicate that these universally intended instruction manuals, in their current format, are open to interpretation, producing unsafe drowning prevention rescue lines that do not meet safety-critical standards. A re-design of the manuals through creative collaboration in a local context are the outcomes of this research. Discussion is also given as to whether a universal instruction manual should be the desirable outcome.

Keywords: *human-centred design, universal design, design for development, interactive prototyping, instruction manual design*

1. Background

There are many challenges to the ambition of reducing global rates of accidental drowning. Not least is how to reduce these numbers at scale in low-income environments, where infrastructure is often too weak to support a fast and effective response, and the cost of procuring technical safety-critical supplies such as ISO standard throw-lines (used by national services such as the RNLI and coastguards) is prohibitively high. The RNLI's response to this has been to develop a set of universal open-source instruction manuals designed to support community makers in the low-volume production of two types of public rescue device that meet rigorous RNLI tested safety-critical standards: a 'bottle ring' line and a 'low volume throw-line'(Figure 1) (RNLI, 2018).
It should be noted that at the stage the authors' research started in early 2019, these community throw-lines and their instruction manuals had already been developed by the RNLI with partners in Bangladesh.

Figure 1. RNLI low-resource rescue equipment designs – throw-line (l) and bottle-ring (r)

These are currently available as open-source resources for lifesavers worldwide. Furthermore, the throw-lines had already undergone rigorous performance testing by the RNLI to standards deemed acceptable to the organisation, in lieu of ISO accreditation. What had not yet been tested rigorously were the manuals.

Collaborative projects between specialised creative universities such as AUB and charities like the RNLI are essential in promoting the relevance of creative thinking, design thinking and creative making skills in the context of complex, problems such as the global drowning crisis. As such, they cannot be addressed through traditional linear and analytical problem solving, they require the inclusion of collaborative relationships between designers and stakeholders in the affected areas (Masys, 2018; Buchanan, 1992). Buchanan (1992) describes design as a discipline with universal scope in which designers form a specific subject based on the problems and issues they address. This, he suggests, makes them uniquely qualified to deal with complex problems. Although not naturally aligned by discipline, but by location and a mutual interest in creative problem solving, the collaboration between the RNLI and AUB is one of those non-linear approaches to addressing the daunting task of halving accidental coastal drowning deaths by 2024 (Royal National Lifeboat Institution, 2015).

Before explaining our rationale to focus on the manuals, the authors wish to acknowledge the broad literature of study that covers the challenges found within knowledge and technology transfer case studies; particularly when critiqued from the approach of transferring from a well-developed economy into a low-income, low-resource environment (Aranda-Jan, Jagtap, & Moultrie, 2016). This study is not an attempt to present another case study on this topic but rather take into account such limitations. The authors acknowledge there will be some level of complexity when delivering a programme of product development designed to embody public health safety-critical standards in other settings. This paper instead offers an outline of a design process that seeks to progress this ambitious multi-stakeholder global delivery programme. There are three key areas of consideration that underpin our rationale.

1.1 Part 1: Community assembly processes

This part of the study drew reasoning from the work of semiotics, particularly 'script' concept. It explores how actants, humans and non-humans, transfer meaning between each other in different settings. This is presented by way of prescribing roles of technologies through acts such as inscription, de-inscription and even re-inscription (Akrich, 1997; Akrich & Latour, 1992). To clarify, this can lead to a variety of often unintended outcomes whereby technical objects simultaneously embodying a set of (sometimes very different) relationships between heterogenous elements, can result in technical objects being re-inscribed with a different script or meaning based on factors existing within the actor's own setting (Akrich, 1997; Verbeek, 2006). In the case of this study, one question was whether communities of makers, such as the ones in Zanzibar, would elect to re-inscribe the throwlines with an alternative script, by way of re-inscribing or even rejecting the RNLI's intended script embodied in the instruction manuals. The intention of the script in this case being to transfer information for throw-line assembly and user handling. The potential importance of re-inscription to the cause of global drowning-

prevention, is a set of products that would likely fail to meet safety-critical standards. In the case of an outright rejection of the manuals there may also be a rejection of the throwline products altogether, leaving communities without the tools to prevent deaths from drowning. So how can designers collaborating with public health experts such as the RNLI, address these concerns and help to develop a set of instruction tools that mediate between the intention of the technical throwline to perform to a safety-critical standard, whilst reducing and managing the risks posed to public safety by re-inscription or rejection. Observing the interactions of makers with the instruction manuals became the focus of this study. The following three questions are now posed:

a) What is the most effective means of communicating instructions for the development of a technical safety-critical product?
b) What are the opportunities and challenges in developing a universal manual of this kind?
c) Is the concept of a universal manual at odds with the goal of human-centred design?

1.2 Part 2: Product testing, use and maintenance in-country

Human-centred design, design for low-resource settings and collaboration with the community were essential in the process of evaluating the assembly process and gathering data of the effectiveness and potential re-design of the manuals. Collaboration with the community in Zanzibar was facilitated by local charity **Pamoja**, an organisation that develops and delivers vocational training to Zanzibar citizens. Pamoja's tailoring school empowers students to take care of themselves and their families by working as professional tailors. To conduct the study permission to utilise the equipment of the tailoring school was obtained for two weeks and participants were found amongst tailoring staff to test the manuals and product assembly process.
Observing the products in context and testing the quality of the products produced by the tailors was facilitated by local charity **The Panje Project**, a grassroots organisation in Zanzibar. The organisation teaches young people and adults how to swim and trains local people in life saving and drowning prevention. Through Panje, a direct connection into the community was formed to help with communication, to link into the community and to support prototype testing in rescue simulations during the second week of the visit. Any future study and impact will likely be conducted in conjunction with Panje who have strong partnerships with formal and informal institutions across the island as well as citizen community networks. The sustainability of Panje's work is tied in part to RNLI International funding. Therefore, any development of a set of goods that can be disseminated and potentially sold through Panje and Pamoja could offer a new source of income.

1.3 Explorative study hypothesis

The AUB Innovation team offer opportunities for individuals, business and charities to work with the university on live projects throughout the year. Working with the RNLI on other throw-line projects, it became apparent that the manuals designed by the RNLI could fail to meet their intended outcomes. Research funding was granted under a UKRI Global Challenges Research Fund (GCRF) to support an explorative study into the effectiveness of the manuals and their products in a DAC country. Issues such as material and equipment availability, cultural sensitivity, and the RNLI's assumption that the makers and users of the product would be the same people helped form the rationale for the study.
Based on the above discussion, the hypothesis for this study proposed that the instruction manuals would fail in their role as community-managed production tools, leading to products that did not meet safety-critical standards.

2. Case study – Zanzibar – Designing out drowning

For low-resource projects to be successful understanding of the context (cultural, material, and developmental) in country is essential (Aranda-Jan et al., 2016). Long distance design projects can highlight issues of empathy between actants and thus require the application of human-centred and low-resource design approaches often promoted for use in sustainable development (Powell & Underwood, 2020). Like many technologies designed for low resource environments the throw-line project had started in the context of a UK design department with some access to local information. Building on

existing international RNLI relationships, Tanzania and Zanzibar were specifically chosen for the initial first study.

2.1. Methodology

Throughout the project several design methods were applied in order to create a collaborative design and manufacturing environment in country. It was imperative to provide room for creative exploration and discussion. Empathy for the local and cultural context was required and core human-centred design approaches were embedded in this study: (1) Looking at what people do, (2) asking people to participate and (3) trying things yourself (Suri, 2003). Through the process of photography and video capture, observational notes and follow-up interviews, all methods of discovery, immersion and connection, a rich data set was compiled (Kouprie & Visser, 2009). All of the applied methods are rooted in traditional product and user-centred design practice.

2.1.1 Defining the project & gathering data

Initially a basic catalogue of defining questions were formulated at the start of the project: *WWWWWH – Who, What, Where, When, Why and How* (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2017). Most of these questions are outlined in section 1 of this paper. It required the involvement of local tailors in their work environments as well as the introduction and formation of a relationship between the local charities The Panje Project and Pamoja.

Figure 2. Co-design/ interaction prototyping session led by local tailors

In Zanzibar data would be gathered using a mix of methods including initial semi-structured interviews with the tailors to establish their level of experience and scope of making ability, as well as their level of confidence in their ability to work with new products and instruction manuals. During the assembly phase each round of prototypes was documented by means of user observation (by video and photo) and semi-structured interviews at the conclusion of each round. The authors recorded the tailors' experience, issues and suggestions. At the end of the prototyping week a final focus group was run to collate the group's overall impressions and suggestions for improvements on supporting manuals and products. A co-designed series of products inspired by an impromptu unfocus group mid-week and expanded by interaction prototyping (Figure 2) led by the local tailors resulted in the development of a number of new potential drowning prevention products (IDEO, 2003).

2.1.2 Prototyping in Zanzibar - Challenges

Several challenges were identified early on. It became apparent during the organisational phase of the exploratory study that the original rescue throwline manuals created by the RNLI made no distinction between the makers and end users of the products. Therefore, a two-part approach to the study was adopted, separating the manual testing from the product testing. Other potential problems identified prior to prototyping included:

- No similar soft goods devices on the market in Zanzibar or Tanzania.
- RNLI manuals in two different formats: a compact bottle ring manual of four A4 pages vs a thirty-page document for the rescue throwline.
- Sourcing of materials in-country.

A list of requirements was created which included the sourcing of materials required for the product manufacture on a local level in country. All materials could be sourced; however, the following issues were raised:

- Bottle size: bottle ring design requires 2 litre plastic bottles. Only 1.5 litres available in Zanzibar. Resulting issues: Buoyancy and size of the bottle-ring – safety critical compliance - potentially fatally compromised.
- Differing rope stiffness: UK polypropylene floating line (more flexible) than Zanzibar polyester floating line (stiffer). This made it potentially more difficult to tie safety-critical knots.
- Coated/UV resistant nylon fabrics are very expensive and hard to source.
- Eyelet installation – only one machine was available at the local market to professionally close the metal eyelets.
- Knot tying: instructions were complex and could be very difficult to interpret, leading to possible major safety shortfalls.

2.1.3 Part 1 - Assembly & manual (video) testing in Zanzibar

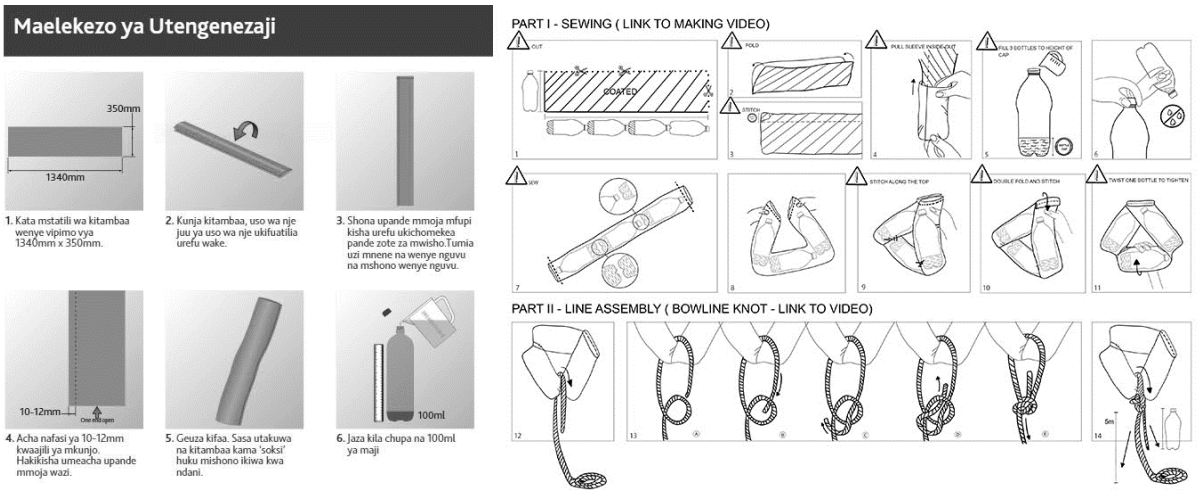

Figure 3. Section of original manual in Swahili. (l) Part 1 of current manual re-development (r)

Four volunteer tailors attended prototyping sessions on five successive days. A shopping list was supplied to Pamoja with instructions on materials and quantities required to produce a maximum of 12 prototypes per design. All materials were sourced at a large local market using chandlery stalls, haberdashery and other related suppliers such as shoe manufacturers. All printed & written manual instructions were provided in Swahili (Figure 3). A translator was found through the local Panje Project network.

2.1.4 Prototyping - How do makers use and interpret manuals?

Prior to prototyping, a baseline was established recording each tailor's experience, their knowledge of soft goods and sewing equipment and their level of confidence with regards to the production of soft goods and rescue equipment in particular. All participants registered a high level of confidence and skill, with some having 20 or more years of tailoring experience. Prototyping was planned in advance taking into consideration the number of designs and supporting instructions, as well as numbers of tailors and days available to manufacture. The work day started at 8:30 and finished at 12:00, allowing participants the opportunity to return to their freelance work in the afternoon. See Table 1 for prototyping instruction overview.

Table 1. Tailors – Prototyping instructions distribution

TAILOR	DAY 1 – TUE	DAY 2 - WED	DAY 3 - THU	DAY 4 – FRI
1	SAMPLE (RING)	MANUAL + VIDEO (LINE)	ALL (LINE)	ALL - OWN MATERIALS (RING)
2	MANUAL + SAMPLE (RING)	MANUAL (LINE)	ALL (BOTTLE)	ALL - OWN MATERIALS (BOTTLE)
3	MANUAL (RING)	SAMPLE (LINE)	ALL (LINE)	ALL - OWN MATERIALS (RING)
4	MANUAL + VIDEO (RING)	SAMPLE + MANUAL (LINE)	ALL (BOTTLE)	ALL - OWN MATERIALS (BOTTLE)

At the start of day 1 and day 2 no additional support or explanations were given to the tailors in this first phase of the prototyping process. This was done to establish what interaction might occur in a non-controlled setting for community tailors who select to use these tools freely. The emerging results indicated that the RNLI manual kits were insufficient to fully complete a sample or open to misinterpretation resulting in prototype samples that were incorrect,. Common issues identified were: (1) Understanding the product dimensions given in millimetres. (2) English into Swahili translation issues for twisting instructions on bottle ring manual. (3) Understanding and replicating complicated knots in both manuals including those instructions shown on the video aids – a key safety-critical feature. (4) No measuring jugs available – 100 ml of water were interpreted as much larger amounts. (4) Fabric orientation – fabric coating was interpreted as waterproofing the product and therefore used on the outside rather than the inside of the product.

Overall, user preference was given to copying by product rather than using a manual but this resulted in safety-critical errors. Greater accuracy in producing a safety-critical product was achieved through a mixture of manual and in prototype. However, this was only following the intervention of the authors providing additional support and explanations alongside RNLI manual instructions.

The tailors found it very challenging to navigate the making process of the first prototype without any further guidance and were prone to making mistakes. Notably the first iteration of the bottle ring prototypes showed a variety of issues, such as material orientation, product size and weight etc. All highlighted as potential problems prior to prototyping under section 3.1.2. The second iteration after review and discussion was produced with confidence and without fault, highlighting the need to revise

Figure 4. 4-bottled bottle ring variations developed with the tailors taking in consideration RNLI instructions for original rescue ring

and rework manual instructions, as well as supporting video aids. During days 3 and 4 interactive prototyping took place, with all tailors utilising their new understanding of the previous days and applying it to the production of new products. Taking into consideration for the new bottle size the participants developed four variations of a 4-bottle ring (Figure 4) with a variety of attachment mechanisms for the rescue rope. In parallel, disregarding the throwlines altogether, two of the tailors independently developed a new type of life raft from the materials provided. Two versions of this raft

were manufactured over the course of prototyping days 3 and 4. The process of designing and manufacturing the rafts was very dynamic with the tailors taking the lead and the authors providing support through the integration of brainstorming and general engineering advice such as buoyancy calculations, aligning the tailor's original design intention with the actual carrying capacity of the raft.

2.1.5 Part 2: Performance testing

Testing to determine the usability and quality of the prototypes produced in-country in comparison to those created in the UK was facilitated by the Panje Project. It also involved the tailors as well as some of their family members in line with the RNLI's intention to create a community-based operation.
The tailors involved in testing could not swim so were given the role of 'lifesaver' whilst Panje participants performed the roles of 'victim' in the water. Each lifesaver was observed on how they used the throw-line device against the intended script (hold, distance/direction of throw, ability to pull in the victim). Some discrepancies were noted between design intention and use, particularly the response of the victim when the device was in the water, a problem which was difficult to rectify through instruction manuals. During this phase of assessment, the team were assisted by the RNLI programme manager for Zanzibar with expert knowledge on how each device should perform. The prototypes were evaluated documenting preference between UK and locally-sourced materials and components; the functionality of the product to save the victim; the quality of the product to withstand storage and manhandling within Zanzibar. All prototypes were found to meet their intended function. Given that the manuals also included instructions for end use, Panje lifesavers were given the opportunity to read through and comment back with any observations. However, no comments to support the redesign of this part of the manual were offered.

3. Evaluation of observations and conversations

The explorative study in-country revealed a number of important findings with regard to designing drowning prevention devices for manufacture in a community context, chiefly:

- Creative collaboration with international charities such as the RNLI is reliant on researching in-country and forming ongoing relationships with formal organisations. The formality of organisations is needed to secure repeat testing of the instruction manuals and usage of throw-lines.
- Involvement of in-country makers - in this case tailors and life savers - is imperative in the development of public rescue throw-lines in low-to-middle income countries.
- Understanding manufacturing capabilities, craftsmanship and local creative talent opens a whole raft of opportunities to produce safety-critical drowning prevention products which have the capacity to engage the community from the onset in drowning prevention efforts, as well as potentially provide a source of income and expertise for local makers and the community. Deviation from the intended production of specific safety-critical products needs closely monitoring to ensure safety-critical standards.
- It is imperative that research employs local expert knowledge of high-risk environments, cultural/social attitudes and political attitudes towards drowning prevention that may constrain or grow drowning prevention interventions (Aranda-Jan et al., 2016).
- For the safety-critical manufacture and safe use of the rescue products the current manuals and use instructions urgently need to be revised and re-designed to enable the community to benefit from production as well as use (Figure 3).

4. Further Development & Conclusions

As initially hypothesised, the exploratory study found that the manuals in their original format were not sufficient to produce safety critical drowning prevention products. As a result of phase 1, the redesign of the instruction manuals has been progressed with a development deadline for June 2020. The MA Design and Innovation students have taken the lead on the redevelopment supported by the RNLI in-house design team and faculty of the Visual Communications degree at AUB.

Human-centred design decisions are informing the re-development such as the removal of all colour to allow for basic photocopying in-country without compromising the quality of the manual and reducing the size to A4. All dimensions have been removed and in the case of the bottle ring the bottles and the bottle cap act as measuring devices for fabric and water content. It is currently being discussed whether a video guide is actually necessary as all of the tailors rejected this as a tool, putting it aside in preference of copying by sample and paper instruction. Instead the creation of country and cultural context specific support kits in the form of finished prototypes and de-constructed prototypes to facilitate accurate safety critical copying, and fabric samples with screen printed cutting patterns, are all under consideration. It has been very difficult to evaluate these changes with the community in Zanzibar, especially under the current global conditions. Additional funding has been secured to test the redeveloped manuals in country.

Providing the tools to allow this project to grow within communities safely but devolved from RNLI's public health expertise is essential in terms of building capabilities and ownership of the rescue process locally. The second phase of the project, utilising the new manuals and co-designing appropriate kits with communities in Zanzibar and in mainland Tanzania is in the planning stages. Participatory Action Research (PAR) will underpin this second phase to allow the local community to conduct their own research, reflection and change (Macdonald, 2012).

It is hoped that, recognising the variance in social values and capabilities for innovation within different communities and regions will lead to different interpretations of products in production and that the findings of this study will therefore result in greater compliance with the RNLI's safety regulations for low resource drowning prevention products, and ultimately, help save more lives.

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