A Mixed-Method Approach: Design of a Novel Sensor System to Measure Cookstove Usage and Fuel Consumption

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***Abstract*— Stakeholders in the improved cookstove sector have called for better monitoring tools to quantify the adoption and technical performance of these devices. To meet this need, researchers at Oregon State University developed the Fuel, Usage and Emissions Logger (FUEL), an integrated logging load cell and temperature sensor that measures household fuel consumption and cookstove usage. This paper outlines the design process of the FUEL system using a mixed-method ethnographic approach that combines qualitative and quantitative data to inform each step in the design process. The ethnographic methods used for field studies in Guatemala, Honduras, and Uganda included participant observation, semi-structured interviews, surveys, and focal follow. Triangulation of these results were used to validate or invalidate design hypotheses. Findings highlight general challenges faced during the design process of humanitarian technologies, including product adaptability, symbolism of "everyday" objects, and pro-innovation bias. Overall, results contribute towards a framework of ethnographic design research for humanitarian technologies.**

Keywords— ethnography, mixed methods, sensor-based monitoring, design, improved cookstove

I. Introduction

Today 40% of the global population continues to rely on traditional open fires to meet their needs for cooking and heating [1]. To mitigate the harmful health and environmental impacts of this common practice, engineers have designed improved cookstoves with a variety of fuel types to increase the efficiency of heat transfer and combustion. Adoption and performance of these devices have been found to vary greatly, depending on the design and its ability to meet user requirements. Stakeholders including academic researchers, non-government organizations (NGOs), funding organizations and climate financing institutions have called for better monitoring tools to quantify the adoption and performance of improved cookstove designs and determine impact. Specified stakeholder requirements include methods that are time and cost-effective and provide accurate, actionable data.

To help meet this need, a research team from the Oregon State University Humanitarian Engineering Program designed the Fuel, Usage and Emissions Logger (FUEL) system, a sensor system consisting of an integrated logging temperature sensor and load cell designed to measure cookstove use and fuel consumption in households, respectively. Development of the FUEL system followed the traditional engineering design process (Fig. 1), and used a mixed-method, ethnographic approach to inform each step in the process.

The use of ethnographic methods that emphasize understanding of user context has increasingly become a central consideration in the engineering design process, which is a series of iterative steps that guide engineers through technology ideation and development [2][3]. User context and needs can be elicited using a mix of qualitative and quantitative ethnographic methods, such as participant observation, interviews, surveys, and focus groups [4]–[6]. The goal of integrating ethnography in the design process is to better understand the end user or customer context, which can improve a designer's ability to adequately address a given need, particularly for customers from a different culture or background [4][7][8].

"Development" or "humanitarian" engineering is a relatively new discipline that focuses on engineering design specifically for low-resource contexts, with the goal of fulfilling basic human needs to alleviate poverty and suffering [9]. Technologies developed to meet these needs should be adaptable to user "error" or preference, and usable while delivering high technical quality [8][10]. However, because there is often considerable distance between the designer and end-user, which refers to not just geographical, but socio-economic status and cultural distance as well, it can be challenging to design and build technologies for these contexts that sufficiently address user needs or preferences [11]. This can result in less potential impact and a drain on resources.

Therefore researchers are calling for use of a mixed-method ethnographic approach to design effective technologies that address basic human needs [12]–[14].

This paper presents the process through which ethnographic methods were used to inform the ideation and development of the FUEL system. The article will outline each step of the engineering design process and demonstrate how ethnographic data were collected and integrated throughout the process.

II. BACKGROUND

A. Motivation of FUEL System

To address the issue of indoor household air pollution and deforestation as a result of traditional open fires used by 2.8 billion people globally, engineers are designing improved cookstoves that increase combustion and heat transfer efficiency [1]. Studies have linked inefficient traditional cooking methods and fuel collection to 3.9 million premature deaths annually from smoke inhalation, as much as 8% of anthropogenic climate change, deforestation, gender inequality, and opportunity costs [15]. However, some studies have found low adoption rates of cookstoves, suggesting that the potential benefits are not always realized [16][17]. Stakeholders including academic researchers, NGOs, funding organizations, and climate financing institutions are calling for rapid, cost-effective and accurate quantification of cookstove usage, fuel consumption, air pollution, and time allocation to measure the impacts of these devices in user households. Daily usage is linked to rates of adoption and time spent on cooking, while fuel consumption can be used to calculate emissions, determine carbon credits and health effects, and determine effects on deforestation and fuelwood collection time.

Sensor-based monitoring can provide objective and long-term profiles of these key measurements [18]–[21]. Various researchers have designed sensors to autonomously measure cookstove body temperature as a proxy for usage and indoor air pollution [22][23]. However, no sensor-based method currently exists to directly measure fuel consumption, a key indicator of cookstove use, technical performance, and social, environmental, and economic impacts. This unaddressed need motivated the development of the Fuel, Usage and Emissions Logger (FUEL) system, which uses an integrated temperature sensor and load cell to directly measure both cookstove usage and fuel consumption in a household.

B. The Engineering Design Process

The modern engineering design process originated in the 1980s, and is intended to guide both academic and practicing engineers through an iterative decision making process that allows them to better identify and meet design and user/customer requirements and constraints [7]. Individual representations of the design process vary, but all follow the basic structure of defining the problem, collecting information, brainstorming and analysis, developing solutions, testing and gaining feedback, and improving the design (Fig. 1, [24]) [3][4][25]. There is significant emphasis on the iterative and fluid, nonlinear nature of this process [26].

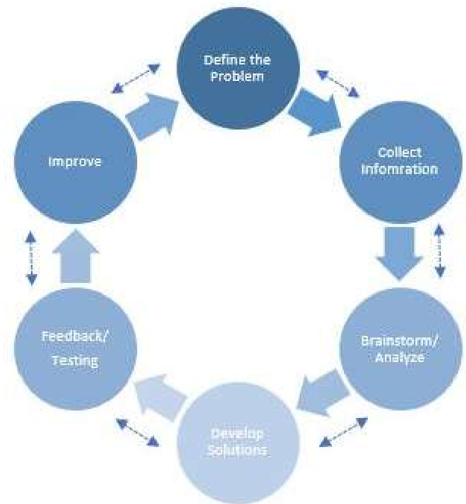

FIGURE 1. The Engineering Design Process [24]

C. Ethnography in Engineering Design

Practitioners have called for the use of a mixed-method ethnographic approach to understand user context, build empathy, and inform the design process. Stemming mainly from the field of anthropology, ethnography is the study of people and their culture, and ethnographic methods are regularly used to understand user context. An overview of key ethnographic methods and their intended purpose is shown in Table 1 [27]. These methods can be both qualitative and quantitative in nature and are often combined in a mixed method approach that allows for triangulation of data from multiple sources. Triangulation of data allows for corroboration and validation of findings [28].

Ethnographic data are interpreted by identifying common themes and patterns. These methods have been applied in the design process in industry settings, with widening recognition of their ability to improve product, service and branding success [29][30]. Consulting firms that use ethnography to inform business strategy and product design (such as IDEO, ReD Associates, Stripe Partners, Flamingo, Gemic) advise high-profile companies such as Nike, Adidas and Samsung. These

TABLE 1. Ethnographic Methods [24]

Technique	Purpose
Background interviews, surveys	Collecting data related to needs and expectations of users; evaluation of design alternatives, prototypes, final design
Focus groups	Small groups of various stakeholders (5-8 people) to discuss issues and requirements
Participant observation, focal follow	Collecting information concerning the environment and culture in which the design will be used
Usability testing	Collecting quantified data related to measurable usability criteria

ethnographic-based consulting firms have helped to create products with higher value to customers and increase profit for companies [31][32].

Ethnographic methods have also been successfully applied to engineering design for development, which focuses on improving conditions for people in poverty [31][32]. Primary goals in this sector are to use engineering within social, environmental and economic contexts to fulfill basic human needs, while increasing quality of life and community resilience [14][33]. Although ambitious goals for meeting these needs such as the United Nation's 17 Sustainable Development Goals (SDGs) have been set [36], technologies and services designed for to meet these goals do not always achieve their intended impact [37].

Inability to reach the goal of improving living conditions often stems from insufficient knowledge of the people and context in which a technology or service is implemented [13], [37]–[39]. A recent analysis of eight development projects found four main modes of failure, including failure to assess needs, understand the culture, assess assets, and apply knowledge [40]. To reduce the chance of these types of failure, practitioners have increasingly used a mixed-method ethnographic approach to the design of humanitarian technologies, while calling for more examples of this work to contribute towards a comprehensive framework of ethnographically-informed design in this context [39].

This paper will present the development of this novel sensor system, using the engineering design process as a methodological framework and describing ethnographic methods used to support each step of the process. From these analyses of the role of contextual data, it will present general conclusions and design considerations that contribute to the framework of integrating ethnography into the design of humanitarian projects.

III. METHODS

The development of the FUEL system will be traced through each step in the engineering design process, with a description and analysis of the ethnographic methods used, data analysis, and resulting design considerations.

1. *Define the Problem*

Designs begin in the ideation phase, where initial stakeholder needs are identified. In this case, problem definition began when student researchers traveled to Guatemala in June 2016 as part of a household energy course through the Humanitarian Engineering Program at Oregon State University (OSU). The course was taught in partnership with the non-government organization (NGO) StoveTeam International, which supports factories in Central America to manufacture and distribute improved cookstoves for rural households. The objective of the course was to learn about and engage in improved cookstove manufacturing, distribution, and monitoring in a real-world setting [41]. OSU student researchers also worked with StoveTeam to measure various impact metrics using a combination of monitoring tools, including surveys and temperature sensors.

TABLE 2. Design Concepts from Brainstorming

Concept	Indicator	Potential Issues
Mobile tracking	*Time*	Legal/privacy issues, high cost to provide phones
24-hour time diary	*Time, school attendance, usage*	Bias, inaccuracy, not long-term
Triggered sensor	*Time*	Inaccurate-difficult to differentiate purpose for entering or leaving
School records and test scores	*Time, school attendance*	May not keep records, tests do not indicate regular attendance
Ask teachers	*Time, school attendance*	Incentive for teachers to fabricate data if they do not show up to class
Load cell	*Fuel, time, usage*	May be invasive

Through observation of the monitoring during this study, researchers identified several shortcomings of existing methods. The surveys were prone to bias and yielded only questionable guesses of firewood collection time, firewood consumption, and stove usage. The temperature sensors required bringing a laptop into households and the resulting data were difficult to interpret. Similar themes are present in the clean cookstove sector at large, where stakeholders have voiced the need to increase transparency and better measure fuel consumption, collection time, cookstove usage, and impacts on education and health. General requirements, assessed through semi-structured interview data with stakeholders in the sector, are that solutions be cost-effective, non-invasive, accurate, and work remotely. Participant observation of current issues with cookstove monitoring allowed the authors to better contextualize and empathize with the problem.

2. *Collect Information*

The next step of the design process is to conduct background research to better define and contextualize the problem. In this case, OSU researchers more closely examined practices of cookstove usage, fuel consumption and education in the intended monitoring context, and the problems with current monitoring methods.

A literature review of monitoring practices for improved stoves revealed issues that agreed with the observational data gathered in Guatemala. Observations of survey inaccuracy agree with the growing body of literature on survey bias [20][42][43]. Although temperature sensors provided more objective measurements than surveys, associated issues included data loss from theft, improper training, and sensor malfunction/data loss due to high temperatures [44].

The ethnographic methods used to collect additional information included participant observation, informal interviews, and surveys. Additional observations and conversations from the field course in Guatemala were used to supplement the literature review and allow for more targeted brainstorming. Stakeholders wanted to more accurately and easily measure fuel collection time and quantity, cookstove usage, and impacts on school attendance. Through participant observation of fuel usage and meal preparations, the research team noted the habitual and deeply-rooted process of firewood collection, storage, and the following meal preparation and cooking. Women would often multitask, which created additional complexity in measuring time and determining what was being done with any spare time.

The researchers also observed typical household size, structure, and layout of home space. Through informal conversations, the researchers learned that teachers in the region were often not motivated to show up regularly to teach and might not always be reliable sources of information on student attendance. It was also noted through semi-structured surveys that some children did not go to school at all because it was too far for them to walk, or they were needed at home to work. The ethnographic methods used also illuminated aspects of the lifestyle, gender relations, and daily rituals that further defined the context in which the problem of more accurately measuring impact metrics was situated.

3. Brainstorm & Analyze

Once initial background information is gathered, the process of brainstorming or concept generation allows designers to experiment with many ideas of varying practicality, and then analyze them against pre-defined technical, user and customer requirements. Based on the prior literature review and ethnographic information collected, a variety of concepts were generated and then analyzed for feasibility and ability to meet the requirements, shown in Table 2. Post-analysis of the observational data showed the central importance of fuel in both the cooking process and as an indicator of multiple metrics of cookstove performance, which in turn inspired the concept of logging fuel weight. Upon evaluation, it was decided that the logging load cell to weigh a household fuel supply was most likely to meet stakeholder requirements, be technically feasible, and measure the most indicators.

It was initially hypothesized that a logging load cell could be used to determine:

(i) the frequency of fuel collection events and amount of fuel collected per event, (ii) fuel consumption per cooking event, (iii) duration of cooking events and number of events, with temperature as a backup measure, (iv) emissions.

It was also hypothesized that the fuel holder could:

(v) be connected to the load cell could be operated in tension or compression (Figures 4 and 5), (vi) double as a carrier during fuelwood collection.

4. Develop Solutions

After choosing the initial concept of a load cell to measure the indicators of stove performance, the system components were designed. The initial prototype system including the load cell, electronics, thermocouple and carrier is shown in Figure 3.

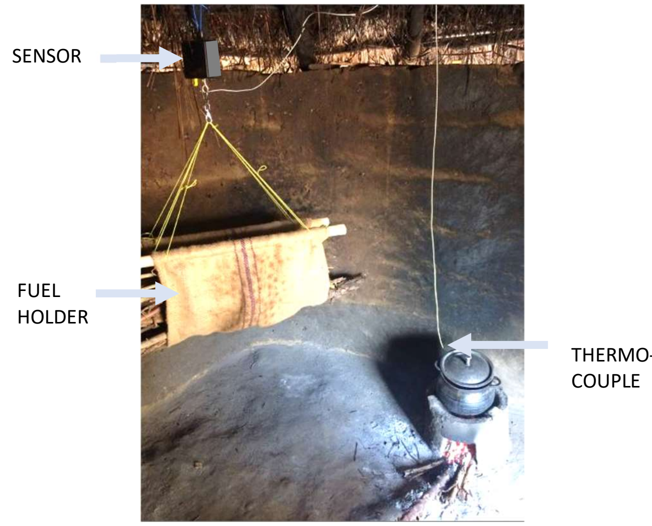

FIGURE 3. FUEL Prototype System

a) Fuel weight measurement and storage: A load cell that could accommodate up to 50 kg of fuel was selected. As shown in Figures 4 and 5, both tensile and compressive load cell configurations were considered in the original system design.

b) Temperature measurement: A thermocouple port was chosen to be flexible in length and accommodate high temperatures.

c) *Electronics, Data Storage & Transmission*: Circuitry design and manufacturing was outsourced to Waltech Systems, a small company in rural Oregon that specializes in custom electronics. Two 1.5 V C batteries were selected to power the logger due to wide availability. To meet the requirement of accurate and remote monitoring, the system was designed to collect data for at least 30 days at a time. Although various modes of wireless transmission were considered, the initial prototype logs data to SD cards, which are reliable, inexpensive, and familiar to field staff.

d) Data Analysis: To translate raw weight and temperature data into metrics of cookstove performance and usage, a simple algorithm was developed to integrate reductions in mass over time. Mass changes are also corroborated with temperature to verify an actual cooking event. Fuel consumption and cookstove temperature are then used to report cookstove usage and duration of a cooking event, and be extrapolated to emissions, carbon credits, and averted Disability Adjusted Life Years (aDALYs) [45].

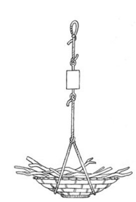

FIGURE 4. Tensile FUEL System

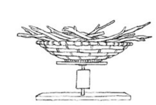

FIGURE 5. Compressive FUEL System

5. Testing/Feedback

Following the first stage of solution development, testing of the prototypes using ethnographic methods to evaluate technical performance and usability was conducted in Central America and East Africa between January and September 2017. All research with human subjects was conducted with oversight by the Oregon State University Institutional Review Board under study number 7257.

To capture accurate data of household fuel consumption, it was imperative to assess the usability of the holder design and ensure that households would not bypass or misuse it during the logging period. Because this method of storage deviates from normal habit, usability testing was a primary focus during the testing/feedback phase of the design process. In addition, questions and study methods were formulated to better understand and define the specific technical, user and customer requirements of the system, shown in Table 2.

Phase 1: San Ramon & Las Brisas, Guatemala, January 2017

In Phase 1, a staff member of StoveTeam International in Guatemala was asked to collect observational and photographic data on typical kitchen size, fuel storage amounts and methods, as well as qualitative information on any perceived issues with the current mechanisms for fuel collection and storage. From these data, it was determined that the roofing structures would be sturdy enough to support the system holding a substantial quantity of fuel, and that floor space may be limited for a scale in compression. The visual data indicated that a typical household fuel supply would not fit in the kitchen space easily, and that it might be challenging to meet hypothesis (i).

Phase 2: El Eden, Honduras, April 2017

Phase 2 was used as a proof of concept test for six prototype FUEL systems in a rural village in El Eden, Honduras, where StoveTeam had recently implemented an improved stove project. The goals of this study were to debrief local staff and participant households, install sensors, and evaluate technical performance and system usability. The FUEL systems with a tension design were installed in households and left to monitor for 30 days. The ethnographic methods used in this phase included focal follow, informal interviews, and participant observation. A focal follow includes documentation of sub-tasks and time spent for a person to perform a specified task. The focal follow of a firewood collection event was conducted to better understand the fuel collection process, evaluate whether the fuel holder could function as a bag for firewood collection, and obtain a rough estimate of a typical collection load. Focal follow data showed that fuel was not always brought directly into the kitchen, and that the amount of firewood collected during a typical trip would not fit into the fuel holders. This provided additional evidence towards invalidating hypothesis (i). The data also indicated that it would be difficult to adapt the fuel carrier to a collection device, hypothesis (vi), based on deviation from habitual practices and size constraint.

Informal interviews indicated that the participants initially viewed the system positively. Accounts included the excitement of one participant's daughter, who rushed to bring back firewood to store in the holder. Another participant stated that he went to collect wood to put in the holder as soon as he saw it. However, although never verbally indicated, one participant seemed less accepting of the system based on initial resistance from her spouse on installing the system in their kitchen and observation of closed-off body language and facial expressions while visiting the household each day. Despite these non-verbal cues, follow-up questioning at the end of the monitoring period yielded only positive feedback from all participants. Although each household gave informed consent and the lead author and translator emphasized the desire for honest feedback, it was recognized that there was still inherent bias to the results. This highlights the need for multiple methods of ethnographic data collection to triangulate and validate findings.

To triangulate findings, the ethnographic data were corroborated with usage data from the FUEL sensors. Results showed that the participant who seemed more uncertain about the fuel holder had only used it approximately 14% of the days monitored, despite temperature data showing that the

TABLE 2. Design Attributes

Design Consideration	Questions Raised	Ethnographic Method	Resulting Engineering Specifications
Sizing, capacity	1. What are current storage methods? 2. Amount of wood per collection event? 3. What is the usual amount of fuel stored in household? 4. Problems with current storage methods?	Participant Observation Semi-Structured Interviews Focal Follow Photography	Dimensions of fuel holder Min/max weight capacity, holder Max weight capacity, load cell Min length, thermocouple Min weight threshold, algorithm
Fuel collection/storage habits	1. In what places is wood generally stored prior to cooking event?	Participant Observation Semi-Structured Interviews Photography	Adaptable to storage habits Keep wood dry
Durability	1. Wear and tear for holder if holding heavy amounts of fuel? 2. Conditions inside kitchen (e.g. rain exposure)	Participant Observation	Water resistant Lifespan of hardware> 2 months
Structural support	Are household roof structures available and sturdy enough to support the system?	Observation Photography	Max weight capacity, system

participant had cooked with the stove most days. The remaining households used the holder 59%, 84% and 100% of the days.

Phase 3: Anenobaer & Ajoodur, Uganda, August 2017

Phase 3 was conducted with International Lifeline Fund (ILF), an NGO that manufactures and distributes improved biomass and charcoal cookstoves in eastern Africa. Based on the relative success of the proof of concept study, a larger pilot study was planned to manufacture, install and evaluate the performance of 100 sensors in Apac, Uganda. The study location was chosen to test the adaptability and applicability of the system when implemented in a different geographic and cultural context. The goals of this study were to debrief local staff and study households, install sensors, and further evaluate technical performance and system usability on a larger scale. The FUEL systems were installed in households and left to monitor for 30 days.

The ethnographic methods used in this study included community meetings, participant observation, informal interviews, focal follow, and semi-structured surveys. Community meetings were held in both villages to explain the purpose of the study, teach participants how to use the system, and elicit initial feedback, questions, and concerns. Participants were generally positive about the system and stated that they preferred the hanging system to one on the ground, which clarified hypothesis (vi). A recurring concern was that the sensors would explode in the households, and participants were assured that this would not happen.

Participant observation and informal interviewing occurred throughout the three-week study. One finding was that women would chop larger pieces of wood into smaller pieces only when they were ready to begin cooking a meal. This indicated that wood might not be placed in the holder until directly before the cook is ready to start the meal, which was evidence towards invalidating hypothesis (i) in this study context. Observation also revealed some potential sources of uncertainty in the FUEL data analysis, such as use of fire starter and smaller kindling that might not be stored in the fuel holder or measured by the sensor.

Further participant observation and a focal follow of one cook preparing a meal using fuel from the holder highlighted the potential difficulty of correlating weight changes to cooking duration and demonstrated that the temperature reading would be necessary to obtain more accurate measurements of cookstove duration (hypothesis (iii)).

A survey comprised of both open-ended and fixed choice questions was also conducted with 50 households after a short uptake period to elicit more structured user opinions, questions about the system and feedback on the effectiveness of the community meeting. An analysis of the 8 households who reported problems is shown in Figure 6. Perceived benefits of the holder were that it kept the wood dry and off the ground. This evidence was corroborated by observations of wood storage habits, as some households had their stacked wood elevated off the ground with bricks, hypothesis (v).

A focal follow of firewood collection in Uganda yielded similar findings to the focal follow in Honduras, and served as another data point that showed that the current fuel carrier might be difficult to double as a collection device since it deviated from well-established methods (hypothesis (vi)).

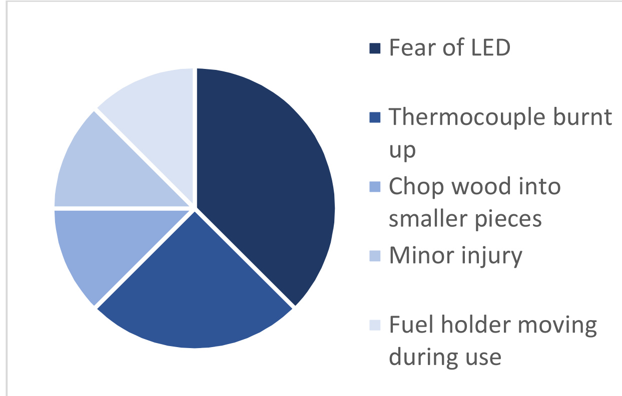

FIGURE 6. Perceived Problems with Fuel Holder

6. *Improve*

The final step in the design process is to make improvements based on testing and feedback. Although this phase is ongoing, several adjustments have been made to the system based on the previous testing.

Based on participants' fear of the LED lights on the sensor and uncertainty of whether the sensor was logging, a light will be added to indicate when the sensor is logging, and the purpose of the additional lights will be explained to households in future deployments or removed.

IV. Results and Discussion

Results highlight both the necessity of integrating ethnography in the design process of the FUEL system, as well as overarching themes that can inform a framework for humanitarian projects.

The problem was clearly defined by stakeholders and was further informed by past ethnographic data from working in Guatemala, observing the deficiencies with current monitoring solutions and context-specific household practices. Participant observation revealed difficulties with current monitoring practices and allowed researchers to more clearly understand the problem, relate to it, and eventually derive an appropriate solution. Observation of localized tasks that were integral to the cooking process allowed for more targeted brainstorming ideas, analysis and follow-up questions. Participant observation of current wood collection and storage methods also allowed researchers to identify that system usability might be a problem that should be considered and further evaluated. This process was also used to identify more general thematic concerns that arise during the design of humanitarian products and services.

Development of the fuel holder was informed by participant observation, focal follow, and informal interviewing. Through these data, researchers ascertained that the holder would not be transformed easily or adopted as a device for collecting firewood in the study contexts. Beginning with the most simplified version of a product and adding additional functionality only after the context is better understood can be a more effective method than creating initial complex solutions. This finding speaks to the concept of pro-innovation bias, which theorizes that engineers and designers are biased towards creating new, disruptive innovations instead of implementing more stable changes [46]. Critics of pro-innovation bias claim that the emphasis on innovation may lead designers to overlook failure and the need for re-design. The inclination to create products with perceived higher utility, such as the fuel carrier that could double as a method of collecting firewood, can lead to time and resources wasted on an unneeded design. This can be mitigated through the use of ethnography early on in the design process to better understand context-specific practices, habits and needs. Although in some contexts the fuel carrier could be of use, it was not found to be a benefit in the study locations.

Through informal interviewing and surveys, it was determined that the LEDs on the sensor scared some participants and that people were also concerned that the sensor would explode. This signifies the importance of recognizing the symbolism of what out-of-context designers may consider "everyday" objects and understanding how these may translate differently to people in different contexts. To an engineer, the light symbolizes a useful indicator of battery life and the wire is clearly a non-explosive device to measure temperature, but to someone in rural Uganda without electricity or with exposure to the dangers of unprofessional electrical wiring, these symbolize an unknown or a potential danger, and induce fear. This agrees with earlier studies that have observed this phenomenon in similar settings [47]. A combination of identifying the symbolism of aesthetic appearance and function during early prototype phase, and adequate explanation of the technology's function can help to mitigate user uncertainty.

Adaptability in the fuel holder was also an important finding. In later study phases, the holders were made using locally available materials, and of a size appropriate to the context. Overall, adaptability is an important design consideration that can help designers more easily make changes and accommodate context-specific, temporally-evolving user needs at any point in the design process. The concept of flexibility in design is part of the adaptable design (AD) paradigm [48], and could be further incorporated into design of humanitarian projects.

Relying on surveys or focus groups alone can introduce bias, and sensor data by itself did not explain how or why the system was or wasn't being used. A combination of triangulated ethnographic and sensor-based methods helped to increase certainty of hypothesis validation or invalidation. For example, observation, surveys, and focus groups triangulated the perceived benefits of storing wood in a hanging holder.

V. CONCLUSION

This article detailed the design of a novel sensor system to measure fuel consumption and cookstove use in low resource contexts using a mixed-method, ethnographic approach. Application of ethnography in this design study contributed towards a framework for future studies, and illustrated challenges faced during the design process of humanitarian technologies, including the influence of pro-innovation bias on designers in creating unnecessary "novel" design, under-examination of the symbolism of "everyday" objects, and the importance of creating easily adaptable products.

Additional feedback and testing will occur in Uganda in summer 2018. This will include usability surveys for all participants and reinstallation of sensors with more robust thermocouples. The sensor data will also be validated against the commonly used Kitchen Performance Test (KPT), in which wood use is weighed manually for 3-7 days [49].

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