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Quantifying the effects of various factors on the utility of design ethnography in the developing world

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Abstract
Ethnography, a tool traditionally used by social scientists, has been adopted by product design engineers as a tool to build empathy, understand customers and their contexts, and learn about needs for a product. This tool is particularly valuable for designers from the developed world working on products for customers in developing communities as differences in culture, language, and life experience make the designer's intuition less reliable in these communities. This paper reports the use of design ethnography under a variety of conditions in the developing world. The data analyzed here come from field studies completed in four different developing communities on four different continents. Researchers had varying degrees of cultural familiarity, language fluency, and community partner participation in each location. Other factors were also included in the study such as the effects of gender and age of the respondents, the ethnographic activity used, and others. Some of the results are intuitive and some are surprising, but all are quantified through rigorous statistical analysis. The results of this study can help design teams of all types including NGOs, student teams, industrial teams, and any other team with an interest in product design in developing communities. These results can help teams plan their own ethnographic activities to increase the likelihood of collecting information that is useful for making product design decisions based on the conditions of their particular project.

Keywords Design ethnography · Poverty alleviation · Design for the developing world · Engineering for global development · Resource-poor · Low resource

1 Introduction

Many engineers and designers have used ethnographic techniques to understand customer needs as they begin developing a new product. Few engineers have reported on the utility of specific ethnographic activities and the factors that affected their ability to collect information that was useful in the product development process. In this paper, we focus on quantifying aspects of design ethnography, specifically for design ethnography conducted in developing communities where differences in language and culture can strongly influence the usefulness of the design ethnography. The aspects quantified in this study include the influences of cultural familiarity, language fluency, ethnographic activity used, information source type, gender and age of the respondent, use of prototypes during ethnographic activities, and the type of need statements collected on the ability of the design team to collect information that is useful in making product design decisions.

The findings described in this paper are particularly useful when designers from developed communities are designing products for customers in developing communities. Designers from the developed world have vastly different life experiences than those living in poverty and are typically unfamiliar with the language, culture, and context of the place where the product they are designing will be used. As a result, their intuition is less reliable for making design decisions about products used in these communities (Allen et al. 2017; Chen et al. 2003; Ramachandran et al. 2007; Jagtap et al. 2014; Viswanathan and Sridharan 2012). For example, as this study began, we used our extensive experience in developing communities and knowledge of the literature to determine three problem areas to focus

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our ethnographic studies on. As researchers arrived in the field, it quickly became clear that none of the three problem areas we had previously identified were of interest to the members of any of the four communities visited. In each location, there were other, more pressing needs that we had not anticipated. This shows the importance of field studies in determining actual customer needs; customer needs are difficult to determine without experience in the context and interaction with potential customers. Without this information, it is difficult for the designer to move forward with the design without making assumptions to fill in gaps in the understanding of customer needs. When these assumptions are the basis for product design decisions, it generally leads to poorer decisions and to products that are less desirable to the intended customers.

In the following section, a review of the literature is presented describing ethnography and its application to product design in developing communities. Next, the experiment is described including more detailed information about each of the conditions and locations. Next, the post field-study analysis is described including the statistical analysis of the data collected. Key results are then outlined along with some discussion of the impact of these results for design teams conducting ethnographic studies. Lastly, some concluding remarks are made about how these results can help all types of design teams plan their own ethnographic activities to increase the likelihood of collecting information that is useful under the conditions of their specific project.

2 Literature review

The word *ethnography* has different meaning in different disciplines (Prabhala et al. 2011; Anderson 1994). Traditional ethnography in the social sciences is the study of other cultures, contexts, and people in their natural settings (Bowling and Ebrahim 2005) as they go about their everyday lives (Emerson et al. 2011). It is the process of learning about and recording the cultural practices of a particular group through immersion and participation in the context of that group (Stewart 1998). Through the ethnographic process, researchers can discover the richness of the human experience, the meaning people give to objects and cultural practices, and understand a different worldview. In the social sciences, ethnography can also refer to a written record of cultural practices (Stewart 1998). Nevertheless, a fundamental purpose of ethnography is to help the ethnographer understand context and culture, whether that culture is as narrow as a profession (e.g., surgeon) or as broad as a geographic region (e.g., Southeast Asia).

The principles of ethnography have been adopted by product design engineers (Wasson 2000). Some argue that while designers use the word *ethnography* to describe their work, this use of the word reveals a misunderstanding of what ethnography is. For example, Anderson asserts that what designers do is not ethnography but a form of reportage (Anderson 1994). Others, like Ball and Omerod, argue that we should distinguish between *pure* or *traditional ethnography* and *applied ethnography*. While there is some overlap in methods and tools, designers perform their studies on a shorter timescale and in a way that focuses on verifiable data instead of first-person story-telling (Ball and Ormerod 2000). They assert that, while designers do not conduct traditional ethnographies, their activities still resemble ethnography and that because these activities provide insight for the design team, applied ethnography is an approach that should continue to be used (Ball and Ormerod 2000). Applied ethnography is a tool that has been used to inform design decisions in Human Computer Interaction for many years (Brooke and Burrell 2003) and its application and use by engineers and computer scientists has evolved over time (Crabtree 1998).

When applied ethnography is used to understand needs for a product, it is typically referred to in the literature as *design ethnography* (Sarvestani and Sienko 2014). Design ethnography can be used to build empathy and to understand customers and their contexts (Salvador et al. 1999). Design ethnography is focused on collecting information about problem-specific context and needs (Salvador et al. 1999), whereas traditional ethnography is focused on the broader purpose of understanding culture and context in a holistic way (Fetterman 2010). Design ethnography is often completed more quickly (hours or weeks) than traditional ethnography (weeks or years) (Sandhu et al. 2007).

The term *design ethnography* is often used synonymously with terms like *user-centered design, human-centered design, participatory design, socio-technical systems design, end-user customization,* and *qualitative methods of requirements capture* (Anderson 1994; Dray and Siegel 2009; Mohedas et al. 2016). The common theme with all of these terms is the focus on the *person* using the product and the *context* in which it will be used.

Some researchers and practitioners have developed frameworks for completing design ethnographies (Hughes et al. 1995; Chipchase and Steinhardt 2013; Green et al. 2006; Human Centered Design Toolkit 2011; The Field Guide to Human-Centered Design 2015; Jagtap et al. 2013, 2014; Aranda et al. 2016) and some have even experimented with creating digital experiences as a way to help others understand a new culture without having to travel (Kim and Underberg 2011). Very few have quantified any aspect of the ethnographic process.

Design ethnography is particularly useful for engineers working on products for customers in the developing world because it helps them to challenge assumptions and better understand their customers. By understanding the life experiences of the customers and what customers value and prioritize in their own cultural context, designers are better able to understand the customers' needs. When customer needs are more accurately understood, the design team is better able to develop a product that meets those needs and has the desired impact (Allen et al. 2017; Wood and Mattson 2016; Thacker et al. 2017; Mattson and Wood 2014; White and White 1986), be it to alleviate poverty or to enter or succeed in a foreign market.

Many researchers have reported on the use of ethnographic techniques as they design products for resource-poor customers. Sarvestani and Sienko (2013, 2014), Sarvestani et al. (2012) and Mohedas et al. (2015) used design ethnography to inform the design of a medical device that improves the safety of a long-standing traditional ceremony in Uganda while maintaining its cultural significance. In this case, the use of ethnography allowed them to collect tacit information from a variety of stakeholders. This information allowed the team to make design decisions that led to a culturally acceptable product. Ambole et al. share a case study in which they point out the importance of designers taking on multiple roles, such as that of design ethnographer, to understand customer needs and to facilitate the co-design process (Ambole et al. 2016). They assert that open-ended and long-term design processes focused on co-design lead to greater social impact in informal settings. Girón et al. (2004) describe how they combined their understanding of the cultural context gained through the use of ethnographic techniques with business marketing and product development skills to help rural indigenous craftswomen diversify their product offering. With this diverse set of products, craftswomen were able to sell more products and products of higher value, increasing their incomes and improving their quality of life. Viswanathan et al. (2011) describe a graduate-level, two-semester course where students learn ethnographic principles and are then immersed in a subsistence market context while learning to identify needs, develop products, and create a business plan that is contextually appropriate.

In the prior work described here, ethnographic techniques are used to improve the impact of a physical product in a developing context, demonstrating the effect ethnographic activities can have on the success of the product. The work presented in this paper is distinct from previous work because the present paper quantifies the influence of various factors on the usefulness of the ethnographic study, allowing design teams to plan their ethnographic activities to maximize the amount of useful information gathered. This information leads to better design decisions and products with greater impact.

3 The experiment

In this section, the conditions of the field studies are described, as are the locations of the field studies. The researchers are described in greater detail. The ethnographic activities are then outlined along with a description of how the information was collected and recorded. Lastly, a description of the timing of each field study is included.

Many factors were also tested throughout this experiment. Some factors did not yield meaningful results but those that did are reported on in this paper. The factors that yielded meaningful results include the effect of the ethnographic activity used, information source type, gender and age of the respondents, use of prototypes, and type of need statements. These factors are described in the following section.

3.1 Description of the conditions

The central question this experiment was designed to answer was how the conditions of cultural familiarity, language fluency, and community partners affect the designer's ability to collect information that is useful for making product design decisions. The products in this case are physical, mechanically-oriented products. The locations of the field studies were chosen to accommodate these conditions and the conditions are described in this section.

While there is much debate about the overlap between language and culture (Kramsch 1998), we chose to separate these two factors for this study to more clearly identify the affect of each. In this study, there were three conditions:

1. Cultural familiarity, language fluency, and community partners.
2. Language fluency and community partners.
3. Community partners only.

The first condition describes a situation in which the researchers are familiar with the culture, fluent in the local language, and have community partners to facilitate ethnographic activities. In this study, a researcher is described as familiar with the culture if they had been immersed in the culture for an extended period of time. While it is unclear exactly what the threshold should be, both researchers who are described as familiar with the culture in this study were previously immersed in the culture—including the specific location chosen for the experiment—for 22 consecutive months. Those researchers described as unfamiliar had typically not spent any time immersed in the culture. In one case, one of the three researchers had spent up to 8 weeks in the location before the experiment began, but the design team was still described as culturally unfamiliar.

The second condition describes a situation in which the researchers are fluent in the local language and have community partners to facilitate ethnographic activities. In this study, a researcher is described as fluent if they are able to express themselves easily and accurately in the local language and easily and accurately understand the spoken and written language.

The third and final condition describes a situation in which the language and culture are unknown to the researchers. In this study, the researchers relied heavily on their community partners and on a translator to perform ethnographic activities in this condition.

A condition without community partners was not included in this study. Our past experiences and what is found in the literature for ethnographic studies indicate that community partners are key because they help researchers build trust with members of the community and that relationship of trust is essential for collecting information. Because significant resources were required to perform an ethnographic study in each location, we chose not to use our limited resources performing a study in a location with no community partners. We did notice that in locations where we had stronger community partners, the researchers were able to conduct ethnographic activities more easily and collect more information.

In each condition, additional factors were also recorded and analyzed. These factors are independent of the condition and include ethnographic activity, source of the information, age and gender of the respondent, use of prototypes, and type of need statement. These factors and their influence on the researchers ability to collect useful information will be described in greater detail.

Table 1 Summary of researchers involved

Researcher	Field studies	Gender	Fluent languages (other than English)
1	India, Rwanda, Spain	Female	None
2	Brazil	Male	Portuguese
3	India, Spain	Male	Spanish
4	Brazil	Male	Portuguese
5	Rwanda	Female	None
6	Rwanda	Male	French

3.2 Description of the researchers

There were a total of six researchers who participated in this study, as summarized in Table 1. Researchers 1 and 2 are the authors of this paper and each led the field studies they participated in. These two researchers also performed all of the coding used in this analysis. Researcher 1 participate in India, Spain, and Rwanda. Researcher 2 participated in Brazil. They were assisted in the field by a total of four additional researchers. Researcher 3 participated in field studies in India and Spain, Researcher 4 participated in Brazil, and Researchers 5 and 6 participated in Rwanda. None of these four additional researchers performed any of the coding.

Each of the six researchers had spent significant time (at least 4 months) in a developing community trying to understand needs previous to the study but this was the first time any of the researchers had conducted a field study with formal training in ethnographic methods and with the goal of collecting publishable data.

3.3 Description of the locations

This experiment in design ethnography is unique because ethnographic activities were conducted in four different developing communities on four different continents, as described in Table 2. The first portion of the study was completed in Itacoatiara, Brazil, a town of 95,700 people along the Amazon River in Northern Brazil. Researchers 2 and 4 completed this field study. They are both American males who are familiar with the culture, fluent in the local language (Portuguese), and had community partners willing to assist with ethnographic activities, as described by condition 1.

The second portion of the study was conducted in a small community on the eastern edge of Madrid, Spain called Cañada Real Galiana. While Spain is not considered part of the developing world, this area was chosen for the study because this section of Madrid is a developing community in many ways. The area is public land and several decades ago, people began building homes there on land they did not officially own. Some residents of this community now have

Table 2 Summary of locations, conditions, and researchers for each field study

Country	Condition	Researchers
Brazil	Cultural familiarity, language fluency, and community partners	2, 4
Spain	Language fluency and community partners	1, 3
Rwanda	Language fluency and community partners (when speaking English or French) Community partners only (when speaking Kinyarwanda)	1, 5, 6
India	Language fluency and community partners (when speaking English) Community partners only (when speaking Telugu)	1, 3

access to basic utilities but there are still unpaved roads, homes made from corrugated metal, and a lack of many of the services that distinguish a community as developed. Members of this community live under the constant threat of being displaced from their homes and have a significantly lower quality of life than their neighbors in the city of Madrid.

Researchers 1 and 3 traveled to Cañada Real Galiana, Spain. They are both are American, one female and one male who is fluent in the local language (Spanish). Both were unfamiliar with the culture and they had community partners to help with ethnographic activities. This location is described by condition 2. Researcher 3 who speaks Spanish is fluent in Peruvian Spanish, which is distinctly different from the Spanish spoken in Spain. Because of this, the words being said were understood but the slang used and the cultural significance of those words was sometimes lost. This allows us to draw some conclusions about the affect of cultural familiarity—or lack thereof—on the researchers' ability to conduct an ethnographic study while still being able to directly communicate with individuals in the community in their own language.

The third portion of this study was conducted mainly in Kigali, Rwanda, a city with a population of 1.1 million people. Excursions were taken to several other cities during the field study. Here, Researchers 1, 5, and 6 conducted the field study. All are American, two female and one male. All are fluent in English, which is one of three official languages in Rwanda, and Researcher 6 is also fluent in French, another official language. The third official language is Kinyarwanda and none of the researchers is fluent in this language. Most ethnographic activities were conducted in English and the remainder were conducted in multiple languages with translation from Kinyarwanda or French to English as necessary. While Researcher 6 had spent two months in Rwanda previously, the other two researchers had no experience with the culture and the research team was considered unfamiliar with the local culture. Overall, this research team was fluent in the language, unfamiliar with the culture, and had community partners willing to help with ethnographic activities, as described by condition 2.

The fourth portion and final of the study was conducted in Visakhapatnam, India, a city of 2 million people on the southeastern coast. Here, Researchers 1 and 3 focused their ethnographic study on a small, lower-income fishing community called Vanivasipalam. Again, these two are American, one female and one male. They were able to conduct some interviews in English, but the majority were conducted through a translator because they were unfamiliar with the local language (Telugu). In this location, the researchers were not fluent in the local language, were unfamiliar with the culture, and had community partners, as described by condition 3.

3.4 Description of ethnographic activities

Before any field studies began, we consulted with a sociologist who has decades of experience conducting ethnographic research and selected four ethnographic activities to use in each location (Emerson et al. 2011; Stewart 1998; Fetterman 2010; Human Centered Design Toolkit 2011; The Field Guide to Human-Centered Design 2015; Martin and Hanington 2012; Kumar 2011; Berg and Lune 2013). The four activities chosen were:

1. Interview—conduct personal and group interviews.
2. Observations—spend time simply observing life in the community.
3. Participation—participate in activities with community members.
4. Community maps—have community members draw maps to show were resources are located, where they spend their time, etc. to understand the layout and resources of the community.

In each country, these activities were adapted slightly to be culturally appropriate.

The researchers found that their participation in activities always turned into interviews because they would ask questions as they were participating to gain deeper understanding. And often, ethnographic activities that started as interviews would include some kind of participation. Because of this overlap, it was difficult to clearly separate the two activities and they were combined into a single group called *interviews* for the analysis.

The community maps activity did yield some useful information but overall, the communities where field studies were conducted do not place the same significance on knowing the precise location of things that Western cultures often do. In communities where locations are often described as a set of directions in relation to key landmarks as opposed to a specific address, the concept of maps was not very culturally relevant. Because of this, so few pieces of information were collected from the community maps activity that it was excluded from the final analysis because none of the results were statistically significant.

Observations consisted of researchers simply being in a setting to watch and record what they saw. During observations, researchers did not interact with people or ask questions and they did not try to synthesize or interpret what they were seeing, they simply wrote what they saw.

As each of the activities were being conducted, the researchers would take quick notes, pictures, and sometimes video to record the events. At the end of each day, the researchers would write a detailed description of the activities of that day (Emerson et al. 2011) in a field report. Information collected in field reports is compared to the information collected through each of the ethnographic activities in this analysis. The ethnographic activities listed previously were recorded separately from field reports. Field reports do not contain quotes from respondents or observations made while conducting a formal observation. Instead, they include the researchers' reflection on the activities conducted, their analysis and interpretation of the information collected, and list of questions to be pursued next.

Respondents were selected for ethnographic activities based on their availability and their relationship to the community partners. In Brazil and India, the researchers spent time walking through neighborhoods or along rows of stores talking with people who were willing to talk. Other ethnographic activities were completed with individuals identified by community partners. In Spain and Rwanda, the researchers relied heavily on partners in the community to arrange respondents for ethnographic activities. In all locations, the researchers tried to balance the number of respondents based on gender, age group, and other characteristics.

Overall, 264 ethnographic activities were documented over the course of this study, resulting in 6050 pieces of data that were used in the analysis.

3.5 Description of the timeline

A different amount of time was spent in each location. In Brazil, the researchers had three separate trips over the span of one year. The first was two weeks in length and the purpose was to conduct an open-ended design ethnography to determine potential product opportunities. The information collected during this trip was given to a graduate product design class and prototypes for four different products were developed. In the middle of the class, about 5 months after the first trip, a second one week trip was taken to conduct ethnographies specific to each of the four products. The information gathered on this trip was used to further develop one of the four products. After another four months of product development, a third trip of one week was taken to continue testing the product with potential users and develop manufacturing partners in the community.

The researchers were in Spain for two weeks doing an open-ended design ethnography and no prototypes were developed.

The researchers were in Rwanda for two weeks and focused on a specific problem area, which was a unique situation in this study as the others began as open-ended studies. This problem area specific approach was chosen because of the validation received from community partners regarding this problem area. The team brought a prototype for use during the field study and additional sketches and other low-fidelity prototypes were also used.

The researchers were in India for 7 continuous weeks. The first 3 weeks were spent doing an open-ended design ethnography and the final 4 weeks were spent focusing on a specific problem area identified during the first half of the field study. Several prototypes were made in the final weeks of the ethnographic study.

4 Analysis

This section describes the process used to organize the data after the ethnographic field studies were completed. Next, the statistical models used in the analysis are discussed, including the necessary equations. We then describe how we can determine the accuracy and appropriateness of the models and how the predictors included in the models were selected, followed by the definition of several statistical terms that will be used as the results are reported.

4.1 Post field-study data processing

Social scientists typically use a process called *coding* to organize data collected through ethnographic activities (Lofland and Lofland 2006; Juliet and Strauss 2008; Dahlberg and McCaig 2010). This coding allows a researcher to draw quantitative conclusions from qualitative data. Coding software allows researchers to develop *descriptors* and *codes* to tag, organize, and compare the data. While this categorization is intrinsically subjective, a set of descriptors and codes was defined and outlined for this study. All of the information collected during field studies was coded by one of two researchers and the researcher coding the information was one of the researchers who participated in the collection of that information. The inter-rater reliability between the two coders was tested and it was found that they were in agreement for 99.48% of the code applications. The descriptor and code definitions are given in this section.

To begin the coding process, a written record of each of the 264 ethnographic activities was uploaded to the coding software. Descriptors were then added to each record; they are tags that apply to the entire ethnographic activity. The descriptors used in this study were:

1. Researcher—identifies the team of researchers who conducted the activity.
2. Country—identifies where the activity was conducted.
3. Condition—identifies which of the three conditions were present (cultural familiarity, language fluency, and community partners).
4. Activity—identifies the activity as a field report or as one of the three activities used to collect information (interview, observation, or community maps).
5. Gender—identifies the respondent as female, male, a mixed group, or not applicable—as in observations.

6. Age—identifies the respondent as a child (0–16), young adult (17–27), middle-aged adult (28–49), senior (50 +), or not applicable—as in a group interview or observations.

The next level of analysis was to tag sections within each record with the appropriate codes. These sections are referred to as excerpts and can range from a few words to a few paragraphs, whichever is necessary to capture the idea that is being coded. Almost all excerpts had more than one code applied to them and some had up to 6 codes. The coding resulted in 6050 excerpts with 22,735 code applications that were used in the analysis.

Typically, the coding process is iterative. First, a set of descriptors and codes was developed based on what we thought would yield the most meaningful results and these codes were applied to the data. The initial codes defined the conditions, locations, ethnographic activities, and other factors in the experiment. As the analysis progressed, we identified additional patterns that would lead to meaningful results that were not part of the original set of codes or recognized that some code definitions needed refining so an updated set of codes was developed. Once these codes were finalized, the data were completely recoded using the final code list. Some codes do not provide any useful results; this is to be expected. These codes were not removed from the description of the final set of codes provided below.

1. Usefulness

    (a) High usefulness—an excerpt that directly influences design decisions (e.g., "this product would be better if it were 6 inches wider", "this hospital has central oxygen but the other hospital uses oxygen tanks", and "500 rupees is the maximum price I would pay for this product").
    (b) Medium usefulness—an excerpt describing a problem to be solved by a potential product (e.g., "everything is wet during the rainy season" and "we would like to have a washing machine") or an excerpt that could potentially influence design decisions or provides a benchmark (e.g., "the most popular mobile phone sells for 8 USD" and "they manufacture 600 products per month").
    (c) Low usefulness—an excerpt that may be useful for understanding the customer or context but that would not directly influence a design decision (e.g., "my older sister studied civil engineering") or an excerpt that is a researcher's note made about the ethnographic process (e.g., "we have completed 40 interviews so far").

2. Source

    (a) Primary source—an excerpt describing a respondent's own experience (e.g., someone describing what they do for a living).
    (b) Secondary source—an excerpt from a respondent describing another person's experience (e.g., describing their neighbor who is unemployed) or excerpts collected through a translator. We chose to code translated information as secondary source because this information was filtered by the translator. Some of what the respondent said was lost and some personal commentary from the translator was added, meaning the translator were describing another person's experience to the researchers.
    (c) Researcher's notes—an excerpt describing a researcher's experience or their analysis of that experience (e.g., "we spoke with Ellen while she was working in the hospital").

3. Interaction setting

    (a) Primary setting—excerpts when researchers were in the place a respondent was describing (e.g., their home, farm, or shop) or when the information was a researcher's note made while in the setting the information is describing (e.g., respondent said "I sold four sewing machines last month" while talking with a researcher in her shop).
    (b) Secondary setting—experts when researchers were with a respondent but not in the place being discussed (e.g., respondent said "The cost of living is higher in Manaus" while in Itacoatiara).
    (c) Not applicable—excerpts where the information is independent of any location (e.g., respondent said "Metal would be stronger than wood without being more expensive, so I'd rather have a metal structure").

4. Context

    (a) Individual—an excerpt that describes someones individual context (e.g., "I've lived in this house for 44 years").
    (b) Societal—an excerpt that describes an aspect of the context shared by many members of the community (e.g., information about government programs in the community).

5. Needs

    (a) Explicit—an excerpt stating a specific need (e.g., "we need a factory to create more jobs").

(b) Implicit—an excerpt that was not stated as specific need but that describes a problem that could be solved (e.g., "there is high unemployment in this community").

6. Prototypes—an excerpt collected while respondents were interacting with prototypes or other hardware (e.g., "it should have walls on all 4 sides").
7. Counting observations—an excerpt that is an observation where something was counted by the researchers (e.g., "the bag of fish was 2 feet by 3 feet by 1.5 feet"). This code was added to determine if attempts to quantify observations led to more useful information.
8. Income—an excerpt containing information about income (e.g., "I make about 40 Brazilian Reais a day").
9. Comments on methods—any researcher's notes made about the ethnographic process as the field study progressed (e.g., "we need to speak to more women to balance our respondents' gender").

The coding process resulted in the following data (Table 3).

4.2 Statistical analysis

The software used to code the data provides analysis functions that are useful for observing general patterns, ratios, and counts, but does not have the capacity for rigorous statistical analysis. For this, the coded information was uploaded into other software called Stata (StataCorp 2015) which was used to analyze and interpret the relationships between the factors coded for. After iterating through several statistical analyses, it was determined that the most accurate and useful results came from the combination of two multiple logistic regression models. A multiple logistic regression model is one that has a binary dependent or outcome variable and multiple independent or predictor variables (Scott Long 1997). Two separate models were needed to analyze this data set because the outcome variable for this study, usefulness, has three categories: low, medium, and high. This refers to the usefulness of that excerpt in making product design decisions.

Table 3 Summary of coded data counts

Country	Number of ethnographic activities	Number of excerpts	Number of code applications
Brazil	158	2092	9638
India	52	1462	4904
Rwanda	41	1715	5587
Spain	13	781	2606
Total	264	6050	22,735

We experimented with other statistical models that accommodate an outcome variable with three categories, specifically the proportional odds model (Liu 2015). This model was inappropriate for the data set because the data set did not meet the parallel lines assumption required for the use of this model.

One of the multiple logistic regression models chosen for this study is a comparison of excerpts coded Low Usefulness to the combined group of excerpts coded Medium Usefulness and High Usefulness. This model will be referred to as the L-MH Model (or Low to Medium and High Model) in this paper and includes all of the 6050 excerpts in the data set.

The other multiple logistic regression model chosen for this study omits the Low Usefulness excerpts and compares the excerpts coded Medium Usefulness to those coded High Usefulness. This model will be referred to as the M-H Model (or Medium to High Model). Because the Low Usefulness excerpts are omitted, the M-H Model includes just 2564 excerpts. It should be noted that this model does not include any excerpts collected in Spain because there were no excerpts from Spain coded High Usefulness. It also does not include any excerpts collected from children for the same reason.

A simple logistic regression consists of a binary outcome variable and just one predictor variable. The equation for this regression is:

$$\ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 X, \tag{1}$$

where p is the probability of success, which is defined as either medium or high usefulness in the L-MH Model or as high usefulness in the M-H Model, β_0 is a constant that describes the intercept, and β_1 is the coefficient associated with variable X, which represents a predictor (Hosmer et al. 2013).

A multiple logistic regression consists of a binary outcome variable and multiple predictors. The equation can be expanded to include i variables as shown:

$$\ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots \beta_i X_i, \tag{2}$$

where β_i is the coefficient for the ith predictor, X_i (Hosmer et al. 2013).

This regression gives a constant, β_0, for the model and a coefficient β_i for each predictor. These coefficients are used to determine the effect each variable has on the researchers' ability to collect information, as described below.

4.3 Determining the accuracy of the L-MH and M-H models

A model consists of both the statistical analysis chosen (in this case, multiple logistic regression) and the variables included in the analysis. When an additional variable is included in the model, it is said to be controlled for Hosmer et al. (2013). When a variable is controlled for, it is given its own term in Eq. 2 and assigned its own coefficient, thus isolating it from the other terms. This removes the effects of the other variables from the coefficient reported, allowing us to report the effect of each predictor independently (Hosmer et al. 2013).

Selecting which predictors to include in a model can be a subjective process that has a significant impact because the predictors included or excluded have an effect on the coefficients reported for the other predictors. There are two key measures that indicate the accuracy of the model and these were used to determine as objectively as possible which combination of predictors was best for this data set.

The first measure of the accuracy of a model is chi squared (χ^2) statistic (Hosmer et al. 2013). Similar to a p value for an individual variable (described below), if the χ^2 statistic is below a certain threshold, the model is said to be statistically significant. As per the standard in the social sciences, the models in this study are said to be statistically significant if $\chi^2 \leq 0.050$ (Hosmer et al. 2013). All of the models described in this analysis have $\chi^2 < 0.0001$ and meet this requirement.

The second measure is called the log likelihood, which is a measure of how well the model fits the data (Hosmer et al. 2013). It is not an absolute measure, but can be used to compare two models. If a variable is added to the model and the log likelihood moves closer to 0, the model is said to be a better fit than before the additional variable was included (Freedman 2009).

To use the log likelihood, we first evaluated an initial model including just one predictor and recorded the log likelihood value of that model. Subsequent predictors were added one at a time and the log likelihood value of each intermediate model was compared to the previous one. If we found that including a specific predictor improved the log likelihood at least ten points in each of the two models, the predictor was included in the final models. Otherwise, the variable was omitted from the models. The predictors that were included in the final models are Ethnographic Activity, Conditions, Gender, Prototypes, Age, Source, Needs, Context, and Income. The following predictors were not included in the models because they did not sufficiently improve the log likelihood: counting observations, interaction setting, researcher, and comments on methods.

4.4 The odds ratio

As described above, each predictor has an associated coefficient, β_i. There is a unique coefficient for each predictor included in the model. When the exponent of the coefficient is taken, the value is known as the odds ratio Hosmer et al. (2013).

$$OR = e^{\beta_i}. \tag{3}$$

Like the log likelihood value, odds ratios are not an absolute measure but can compare one predictor to another. Equation 4 gives further meaning to the odds ratio.

$$OR = \frac{p(1)/(1-p(1))}{p(0)/(1-p(0))}. \tag{4}$$

The numerator is the odds of a successful outcome over the odds of failure when the predictor is equal to 1. The denominator is the odds of a successful outcome over the odds of failure when the predictor is equal to 0. This gives the likelihood of success with one predictor over another (Hosmer et al. 2013).

There are two ways to report an odds ratio. First, an odds ratio can be reported for a predictor as a whole. This is useful when the predictors are continuous or ordered variables, such as temperature. For example, if the odds ratio for temperature was 1.645, it means that a successful outcome is 1.645 times more likely as the temperature increases. In our data set, the predictors are categorical variables, meaning there are discrete values but these values are not necessarily ordered. For example, the predictors gender has four discrete values: (1) not applicable (as in observations), (2) female, (3) male, or (4) a mixed gender group. These values cannot be meaningfully ordered so one odds ratio for the entire predictor is not as meaningful (Hosmer et al. 2013).

The second option for reporting odds ratios is to compare one category within each categorical predictor to another. This allows us to report the odds of collecting useful information between two specific categories of a predictor (e.g., female vs. male respondents) (Hosmer et al. 2013). This is how the results will be reported in this paper.

Each odds ratio has an associated p value which describes the statistical significance of that odds ratio. Again, as per the standard in the social sciences, an odds ratio in this study is said to be statistically significant when $p \leq 0.050$ (Brase and Brase 2013). While an odds ratio will still be reported by the software if the p value is above this threshold, the results are not statistically significant. This does not mean the predictor has no impact on the outcome variable; it simply means that the model gives no indication of what the impact is (Hosmer et al. 2013).

As each odds ratio is an estimated value based on the data, each odds ratio also has an associated 95% confidence interval. This is a range of odds ratios between which we are 95% confident the actual odds ratio falls. The higher the reported odds ratio, the larger the 95% confidence interval (Hosmer et al. 2013). For simplicity, these intervals are not reported in the text of the paper, but are included in Tables 4 and 5. Each p value will be reported to one significant figure and the odds ratios and confidence intervals will be reported to two decimal places (Cole et al. 2015).

5 Results and discussion

In this section, we will describe the results found through statistical analysis of the data. Many of the results described here are intuitive but the value of this study is that it quantifies, at least for this data set, the relative likelihood of collecting information that is useful for product design for each predictor. Other results described here are counter-intuitive and should be considered by designers as they prepare to conduct their own ethnographic studies.

The majority of the results reported here came from one of two statistical models, the L-MH Model and the M-H Model. There are also six additional models that provide deeper insight into the results of the condition predictor (Hilbe 2009). These additional models will also be described in this section.

The results of each predictor will be reported individually as the other variables in the models have been controlled for by including them in the model; this means that the results of each variable reported are independent of the effects of the other variables in model. After the results are listed, there is some discussion of how those results can be used by designers planning their own design ethnographies. The implications of these results will be discussed in greater depth in Sect. 5.

5.1 Influence of condition

The condition predictor is the one that most influenced the locations chosen for this study. Some of the results for this predictor were very intuitive and some were not. In an effort to gain a deeper understanding of these counter-intuitive results, the 6 additional models were used (Hilbe 2009).

As shown in Table 5, the M-H Model gave the following results for the condition:

Table 4 Results from L-MH Model

Predictor 1	Compared to Predictor 2	p value	Odds ratio	95% confidence interval	
				Lower limit	Upper limit
Community partners only	Language fluency and community partners	< 0.001	1.502	1.228	1.839
Community partners only	Cultural familiarity, language fluency, and community partners	< 0.001	2.499	1.876	3.328
Language fluency and community partners	Cultural familiarity, language fluency, and community partners	< 0.001	1.663	1.305	2.120
Interviews	Observations	< 0.001	40.021	20.204	79.274
Field reports	Observations	< 0.001	3.144	2.245	4.401
Interviews	Field reports	< 0.001	12.731	6.934	23.374
Primary sources	Secondary sources	0.698	Not statistically significant		
Primary sources	Researchers' notes	< 0.001	1.903	1.578	2.296
Secondary sources	Researchers' notes	< 0.001	1.978	1.621	2.413
Women only	Men only	0.647	Not statistically significant		
Mixed gender group	Women only	0.964	Not statistically significant		
Mixed gender group	Men only	0.937	Not statistically significant		
Gender not applicable	Women only	0.001	4.415	1.813	10.748
Gender not applicable	Men only	0.002	4.235	1.732	10.357
Gender not applicable	Mixed gender group	< 0.001	4.349	2.421	7.812
Children	Young adults	0.013	1.933	1.151	3.247
Middle aged	Children	0.296	Not statistically significant		
Seniors	Children	0.271	Not statistically significant		
Middle aged	Young adults	< 0.001	1.476	1.225	1.779
Seniors	Young adults	0.020	1.416	1.056	1.899
Middle aged	Seniors	0.761	Not statistically significant		
Prototypes used	Prototypes not used	< 0.001	31.321	21.642	45.328
Explicit need statements	Implicit need statements	0.011	1.747	1.138	2.681

The predictor in the first column is being compared to the predictor in the second column. For example, the first row is interpreted as "the community partners only condition is 1.502 ($p < 0.001$) times more likely to give medium or high usefulness information than the language fluency and community partners condition"

Table 5 Results from M-H Model

Predictor 1	Compared to Predictor 2	*p* value	Odds ratio	95% confidence interval	
				Lower limit	Upper limit
Language fluency and community partners	Community partners only	< 0.001	5.000	3.424	7.300
Cultural familiarity, language fluency, and community partners	Community partners only	< 0.001	18.480	10.838	31.510
Cultural familiarity, language fluency, and community partners	Language fluency and community partners	< 0.001	3.696	2.276	6.003
Interviews	Observations	0.003	4.484	1.642	12.246
Field reports	Observations	< 0.001	6.621	3.435	12.760
Interviews	Field reports	0.363	Not statistically significant		
Primary sources	Secondary sources	0.008	1.516	1.115	2.062
Primary sources	Researchers' notes	0.344	Not statistically significant		
Secondary sources	Researchers' notes	0.087	Not statistically significant		
Women only	Men only	< 0.001	1.778	1.312	2.408
Mixed gender group	Women only	0.501	Not statistically significant		
Mixed gender group	Men only	0.908	Not statistically significant		
Gender not applicable	Women only	0.640	Not statistically significant		
Gender not applicable	Men only	0.254	Not statistically significant		
Gender not applicable	Mixed gender group	0.039	2.423	1.046	5.613
Middle aged	Young adults	0.027	1.450	1.043	2.015
Seniors	Young adults	0.394	Not statistically significant		
Middle aged	Seniors	0.527	Not statistically significant		
Prototypes used	Prototypes not used	< 0.001	7.794	5.807	10.463
Explicit need statements	Implicit need statements	< 0.001	4.925	3.308	7.332

The predictor in the first column is being compared to the predictor in the second column. For example, the first row is interpreted as "the language fluency and community partners condition is 5.000 ($p < 0.001$) times more likely to give highly useful information than the community partners only condition"

1. Having language fluency and community partners led researchers to be 5.000 ($p < 0.001$) times more likely to collect highly useful information than having only community partners.
2. Having cultural familiarity, language fluency, and community partners led researchers to be 18.480 ($p < 0.001$) times more likely to collect highly useful information than having only community partners.
3. Having cultural familiarity, language fluency, and community partners led the researchers to be 3.696 ($p < 0.001$) times more likely to collect highly useful information than having only language fluency and community partners.

This pattern is to be expected but these results show, for this data set, just how much more effective a design team can be when they are familiar with the culture or fluent in the local language. The odds ratios indicate that the impact of language fluency is greater than the effect of cultural familiarity. They also show that the combination of cultural familiarity and language fluency have a very significant impact on the ability of the design team to collect information that is highly useful for making product design decisions.

This indicates that design teams should choose projects in locations where they have cultural familiarity and language fluency in addition to community partners whenever possible. If having both is not possible, choosing projects in locations where they have language fluency should be a priority so they can communicate directly with respondents as much as possible.

As shown in Table 4, the L-MH Model gave the following results:

1. Having community partners only led the researchers to be 1.502 ($p < 0.001$) times more likely to collect information coded medium or high usefulness than having language fluency and community partners.
2. Having community partners only led the researchers to be 2.499 ($p < 0.001$) times more likely to collect information coded medium or high usefulness than having cultural familiarity, language fluency, and community partners.
3. Having language fluency and community partners led the researchers to be 1.663 ($p < 0.001$) times more likely to collect information coded medium or high usefulness

than having cultural familiarity, language fluency, and community partners.

The pattern here is opposite of the previous model and of what was expected for the condition predictor. The results show that having community partners only is the most effective condition for collecting information coded as medium or high usefulness, followed by language fluency and community partners, and that cultural familiarity, language fluency, and community partners is the condition least likely to give information coded medium or high usefulness. This unexpected pattern may have several factors that contribute to it, one of which is undoubtedly the high number of low usefulness excerpts collected in Brazil as shown in Table 7. This pattern will be discussed in greater detail below.

To begin exploring other possible causes of the counterintuitive L-MH Model results for the condition predictor, we analyzed several additional models. These additional models allowed us to test hypotheses regarding the potential causes. In the end, there were six additional models that provided deeper insight. The models are described in Table 6

Additional Models 1 and 2 were similar to the L-MH Model and the M-H Model, respectively. The only difference was that the condition predictor was replaced with the country predictor in each case. The country variable was not used in either of the original L-MH or M-H Models. Additional Models 1 and 2 allow us to determine if the results from the L-MH Model were based on a country-specific affect. The condition and country predictors are the same except for 2 cases:

1. When ethnographic activities were conducted with English speakers in India, moving the activity from a community partners only condition to a language fluency and community partners condition. This affected 12% of the excerpts from India.

Table 7 The number of excerpts in each category of usefulness by country

	Spain	India	Brazil	Rwanda
Low usefulness	709	749	1256	772
Medium usefulness	72	589	357	632
High usefulness	0	124	479	311

2. When ethnographic activities were conducted in French or Kinyarwanda in Rwanda, moving the activity from the condition of language fluency and community partners to community partners only.

The results for Additional Models 1 and 2 are listed in Table 11. Additional Model 1 shows that the location where researchers were most likely to collect information coded medium or highly useful was Rwanda, followed by India, then Brazil, and finally Spain. Additional Model 2 shows that the location where researchers were most likely to collect highly useful information is Brazil, followed by Rwanda, and then India. There was no statistically significant odds ratio comparing Brazil and Rwanda.

This is a different pattern than was indicated by the results of the L-MH and M-H Model using the condition predictor but still not the order we would have intuited– namely that Brazil would be the country most likely to yield useful information because the condition in that location was cultural familiarly, language fluency, and community partners. This confirmed our hypothesis that the difference was caused, at least in part, by something specific to the location.

Our next hypothesis to be tested related to what could have been different in each location. Surely the culture in each location had an effect. For example, in some locations the culture is more time-bound making it easier for researchers to plan their activities and keep appointments which affected their ability to collect information. But we do not have the appropriate codes to test for that particular effect. As described in Sect. 2, the degree to which the

Table 6 Description of the additional models used in the analysis

Model name	Low vs. medium and high (L-MH) usefulness or medium vs. high (M-H) usefulness	How model differs from initial L-MH or M-H model	Number of excerpts included in model
Additional Model 1	Low vs. medium and high (L-MH)	Condition predictor is replaced with country predictor	6050
Additional Model 2	Medium vs. high (M-H)	Condition predictor is replaced with country predictor	6050
Additional Model 3	Low vs. medium and high (L-MH)	Excerpts collected in open-ended ethnography only	2705
Additional Model 4	Medium vs. high (M-H)	Excerpts collected in open-ended ethnography only	2705
Additional Model 5	Low vs. medium and high (L-MH)	Excerpts collected in problem-area focused ethnography only	3345
Additional Model 6	Medium vs. high (M-H)	Excerpts collected in problem-area focused ethnography only	3345

ethnographic study was focused on a specific problem area was different in each of the countries and this is a hypothesis we were able to test with our codes. To test this, each of the excerpts were divided into two groups: those collected during open-ended ethnographic activities and those collected during problem-area specific ethnographic activities.

The first group, open-ended ethnographic activities, included all activities in Spain, most of the activities from the first 4 weeks in India, activities from the first field study in Brazil, and none of the activities from Rwanda.

The second group, problem-area specific ethnographic activities, included no activities from Spain, the remainder of the activities from India, activities during the second and third field studies in Brazil, and all of the activities conducted in Rwanda.

Once the excerpts had been grouped into these two categories, Additional Models 3 through 6 were performed. The results are listed in Table 12. Each of these four models was analyzed first with the condition predictor, followed by the country predictor and all results are in the table.

The results of Additional Model 3 indicate that when design teams begin with an open-ended ethnography, they are most likely to collect information coded medium or high usefulness in a the condition of community partners only, followed by the condition of language fluency and community partners, and least likely to collect information coded medium or high usefulness in the condition of cultural familiarity, language fluency, and community partners. This is the same order as the original L-MH Model.

The condition of community partners only may be the most likely to provide useful information because this is the only condition that requires a translator. The information collected through a translator in this study was not recorded and transcribed word-for-word; the information was translated on the spot and recorded by the researchers. This means that the translator heard all of the responses from members of the community and had to immediately choose which responses to translate. The translator made these decisions based on what he thought would be of most interest to the researchers and in this process, much of the less useful information was not translated and recorded by the researchers. This means that statements respondents made were not recorded and included in the analysis which helps explain the results from Additional Model 3.

Without a translator to filter the less useful information, the researchers in the cultural familiarity, language fluency, and community partners condition were exposed to more information—a large portion of which was low on the scale of usefulness for making product design decisions as shown by Table 7. The increased amount of information collected and the lack of an external filter meant that the researchers recorded a higher amount of low usefulness information. This decreases the numerator in the odds ratio equation for the condition of cultural familiarity, language fluency, and community partners, lowering the odds ratio for this predictor as shown by Additional Model 3.

In Additional Model 4, several of the predictors were collinear and were removed from the model by the software. After removing the collinear predictors, there were an insufficient number of excerpts remaining to conduct a statistically significant analysis so there are no results from this model.

The results from Additional Model 5 show what we would expect: that having cultural familiarity, language fluency, and community partners is the condition in which researchers are most likely to collect information coded as medium of high usefulness for product design, followed by the language fluency and community partners condition, followed lastly by the community partners only condition. It is instructive to note that, while Additional Model 5 follows this pattern, the odds ratios indicate that the differences between the conditions are relatively small. This means that for this data set, design teams with cultural familiarity and language fluency did not have a large advantage over teams with only community partners in collecting information that was coded as medium or high usefulness. The results for Additional Model 6 show the same pattern, but the odds ratios are much higher, indicating that design teams with cultural familiarity and language fluency did have a distinct advantage when it came to collecting information that was highly useful for making product design decisions. These results together indicate that designers conducting problem-area focused ethnographies in conditions where they have only community partners will still be able to collect useful information, but they will lack the ease of communication that facilitates the collection of highly useful information. This may cause designers to make assumptions to fill in gaps in their understanding of customer needs which often leads to less desirable products.

The six additional models provided a greater understanding of the effects of the condition predictor on the ability of the researchers in this study to collect information that is more highly useful. The results of Additional Models 1 and 2 make it clear that the counter-intuitive results were caused by some factor specific to each location and Additional Models 3 through 6 make it clear that a significant factor was the degree to which the researchers were focused on a specific problem area during their ethnographic study.

All of the results shared in the remainder of this section are from the L-MH and M-H Models and are summarized in Table 8 for comparison. We chose to use these models because they include all of the data and because they give the broadest patterns for assisting design teams planning their own design ethnographies.

Table 8 Results from the L-MH Model and M-H Model side by side

Predictor variable		L-MH Model		M-H model	
Predictor 1	Compared to Predictor 2	*p* value	Odds ratio	*p* value	Odds ratio
Interviews	Observations	< 0.001	40.021	0.003	4.484
Field reports	Observations	< 0.001	3.144	< 0.001	6.621
Interviews	Field reports	< 0.001	12.731	0.363	–
Primary sources	Secondary sources	0.698	–	0.008	1.516
Primary sources	Researchers' notes	< 0.001	1.903	0.344	–
Secondary sources	Researchers' notes	< 0.001	1.978	0.087	–
Women only	Men only	0.647	–	< 0.001	1.778
Mixed gender group	Women only	0.964	–	0.501	–
Mixed gender group	Men only	0.937	–	0.908	–
Gender not applicable	Women only	0.001	4.415	0.640	–
Gender not applicable	Men only	0.002	4.235	0.254	–
Gender not applicable	Mixed gender group	< 0.001	4.349	0.039	2.423
Children	Young adults	0.013	1.933	–	–
Middle aged	Children	0.296	–	–	–
Seniors	Children	0.271	–	–	–
Middle aged	Young adults	< 0.001	1.476	0.027	1.450
Seniors	Young adults	0.020	1.416	0.394	–
Middle aged	Seniors	0.761	–	0.527	–
Prototypes used	Prototypes not used	< 0.001	31.321	< 0.001	7.794
Explicit need statements	Implicit need statements	0.011	1.747	< 0.001	4.925

The predictor in the first column is being compared to the predictor in the second column. For example, the first row is interpreted as "interviews are 40.021 ($p < 0.001$) times more likely to give medium or highly useful information and 4.484 ($p = 0.003$) times more likely to give highly useful information than observations"

5.2 Influence of ethnographic activity

We started with a set of four ethnographic activities to test: interviews, observation, participation, and community maps. As described in Sect. 1, participation and interviews were combined into a single category and community maps was excluded from the analysis because so few excerpts were collected through this activity. Another activity, field reports, was added to the list after the analysis showed that a significant amount of information was collected through these reports. This leaves 3 activities in the final analysis: observations, interviews, and field reports. The influence of the ethnographic activity predictor from the L-MH Model are:

1. Interviews were 40.021 ($p < 0.001$) times more likely to result in information that was coded medium or high usefulness than observations.
2. Field reports were 3.144 ($p < 0.001$) times more likely to result in information that was coded medium or high usefulness than observations.
3. Interviews were 12.731 ($p < 0.001$) times more likely to result in information that was coded medium or high usefulness than field reports.

The influence of the ethnographic activity predictor shown by the M-H Model are:

1. Interviews are 4.484 ($p = 0.003$) times more likely to result in highly useful information than observations.
2. Field reports are 6.621 ($p < 0.001$) times more likely to result in highly useful information than observations.
3. There is no statistically significant result comparing interviews and field reports for collecting highly useful information ($p = 0.363$).

These results show that, for this data set, conducting interviews is by far the activity that is most likely to lead to useful information. Interviewing is also the activity that provided the bulk of the excerpts. This activity was most common in part because it was the least formal. In each community, people were generally willing to talk with researchers but were less willing to show them into their homes or host an event they could participate in. Interviews required the least amount of the respondent's time, energy, or planning and were therefore the most common way for respondents to engage with the researchers.

Field reports took significant effort to generate but they were helpful to the researchers in two ways: first, recording the events of the day forced the researchers to be aware of how the ethnographic study was being conducted, which things were working well and which were not. This analysis allowed the researchers to make more conscious decisions about their ethnographic activities. Second, it was a way for researchers to process and synthesize the information they were collecting. Field reports can allow the designers to clearly see what has been learned and what the next most pressing questions are.

Observations provided no interaction with people and was the activity that led to the least useful information, indicating that the interaction with people in a community is the essential factor for collecting more highly useful information. But observations should not be completely discounted. Observations of the community in general helped researchers become familiar with the context. These observations were particularly useful during the first few days of each study but these observations were too broad and unfocused to be useful for making product design decisions. Researchers found that using observations was effective again after they had a specific problem area to focus on. Observations of someone solving the problem in the traditional way or of using a prototype did lead to information that was useful in making design decisions. Much can be learned from observing the differences between what people say and what they do (Human Centered Design Toolkit 2011) and these observations can only be made in the field.

These results from this study clearly indicate that if the team has limited time in the field, interviews are the most efficient ethnographic activity for collecting information that will be useful for product design decisions. Design teams should consider that there is some information that can not be acquired through interviews (e.g., observing differences between peoples' words and actions) so a variety of ethnographic activities should still be planned for. In addition, keeping a field report allows the designers to record information that is useful for product design and allows them make more conscious decisions about how to conduct their ethnographic study as they spend time in the field.

5.3 Influence of the source of information

There are three sources that were analyzed in this study: primary sources, secondary sources, and researchers' notes. The effect of source as shown by the L-MH Model are:

1. Primary sources are 1.903 ($p < 0.001$) times more likely to provide information that was coded medium or high usefulness than researchers' notes.
2. Secondary sources are 1.978 ($p < 0.001$) times more likely to provide information that was coded medium or high usefulness than researchers' notes.
3. There was no statistically significant result comparing primary and secondary sources for likelihood of providing information of medium or high usefulness ($p = 0.698$).

The effect of source as shown by the M-H Model are:

1. Primary sources were 1.516 ($p = 0.008$) times more likely to provide information that was highly useful than secondary sources.
2. There was no statistically significant result comparing primary sources and researchers' notes for likelihood of providing highly useful information ($p = 0.344$).
3. There was no statistically significant result comparing secondary sources and researchers' notes for likelihood of providing highly useful information ($p = 0.087$).

These results from the L-MH Model indicate that both primary and secondary sources were more likely to provide information of medium or high usefulness than researchers' notes. The results from the M-H Model indicate that primary sources are more likely to give highly useful information than secondary sources. This means that talking with someone about their own situations or talking with someone about another person's situation are almost equally likely to result in useful information, but that highly useful information is more likely to come from talking with someone about their own experience.

The results of the L-MH Model also show the importance of interactions with members of the community, as both primary and secondary sources are more likely to provide more highly useful information than researchers' notes. But there was still highly useful information collected through field reports. These notes are a useful source of information because they are made as the researchers synthesize the information they are collecting from people. This synthesis is a necessary step in concluding what the customer needs are and how the information collected will affect design decisions for the product.

5.4 Influence of gender

Gender was another predictor that had an impact on the researchers' ability to collect useful information. As shown in Table 9, a higher number of the total ethnographic activities involved men, less involved women, and significantly less involved a situation where gender was not applicable (such as in observations and field reports) or a mixed gender group. The L-MH Model provides the following results:

1. There was no statistically significant result comparing women to men for collecting information coded medium or high usefulness ($p = 0.647$).

Table 9 Percentage of ethnographic activities completed by each gender group

Gender group	Percentage of activities (%)
Men	42.3
Women	38.4
Not applicable	10.6
Mixed group	8.8

2. There was no statistically significant result comparing mixed gender groups to either women alone ($p = 0.964$) or men alone ($p = 0.937$) for collecting information coded medium or high usefulness.

The M-H Model provides the following results:

1. Women were 1.778 ($p < 0.001$) times more likely to give highly useful information than men.
2. There was no statistically significant result comparing mixed gender groups to either women alone ($p = 0.501$) or men alone ($p = 0.908$) for collecting highly useful information.

Most of the results for this predictor in both models were not statistically significant. This does not mean that gender has no impact on the researchers' ability to collect useful information; it simply means that the model cannot tell us what that impact is.

The results that were statistically significant in the M-H Model indicate that women are more likely than men to provide useful information. Because women are more affected by poverty alleviation efforts than men (Mattson and Wood 2014) and because they are more likely to provide highly useful information, design teams should carefully consider the gender balance that will most benefit their ethnographic study.

We believe that more of the activities were completed by men in this data set because of the six researchers involved, four are men. The researchers made an effort to keep a balanced group of respondents but it was more comfortable and often more culturally appropriate for men to speak with other men individually than with women individually. While the researchers in this particular experiment could have sought out more female respondents for ethnographic activities, the fact remains that this is not an uncommon occurrence for design teams conducting ethnographies.

There are several social factors influencing this imbalance. One is that engineering in Western countries is a male-dominated profession. In the USA, only 14% of professional engineers are women (Beede et al. 2011). In Canada, only 12.8% of licensed engineers are women (National Membership Report 2018). And in the UK, only 9% of engineering and technology professionals are women (2016 IET Skills Survey 2016).

This means that men are likely making up the majority of the design teams conducting field studies. The second factor is that developing communities typically have more traditional, formal, and patriarchal cultural contexts. These factors combined make it difficult for design teams to access female respondents.

Design teams can overcome this challenge by: (1) including more female engineers in the field study to conduct the ethnographic activities, and (2) by more actively seeking female respondents for those activities. The results from this data set show that female respondents are more likely to provide information that is highly useful for product design decisions so it is worth the extra effort that may be required to interact with them.

5.5 Influence of age

The age of respondents in the ethnographic activities also influenced the ability of the researchers to collect useful information. The results from the L-MH Model show:

1. Middle aged respondents were 1.476 ($p < 0.001$) times more likely to provide information coded as medium or high usefulness than young adults.
2. Seniors were 1.416 ($p = 0.020$) times more likely to provide information coded as medium or high usefulness than young adults.
3. Children were 1.933 ($p = 0.013$) times more likely to provide useful information than young adults.
4. There was no statistically significant result comparing seniors to middle aged respondents ($p = 0.761$) for providing information coded as medium or high usefulness.
5. There was no statistically significant result comparing children and middle aged respondents ($p = 0.296$) or seniors ($p = 0.271$) for providing information coded as medium or high usefulness.

The M-H Model shows:

1. Middle aged respondents are 1.450 ($p = 0.027$) times more likely to provide highly useful information than young adults.
2. There was no statistically significant result comparing seniors to either young adults ($p = 0.394$) or to middle aged respondents ($p = 0.527$) for providing highly useful information.

This predictor also provided only a few statistically significant results. The results do indicate that, while useful information was collected from individuals in each age category, middle aged respondents as a group were most likely to provide information that was highly useful for product development decisions. They also indicate that young adults were the group least likely to provide useful information.

The decision of which age group the design team engages with may depend on the type of product being designed and the intended customers for that product. Generally, respondents from a variety of age groups should be involved in ethnographic activities because each age group will have a different perspective and different insights that may be helpful to product designers.

5.6 Influence of prototypes

For the communities in India, Brazil, and Rwanda, physical prototypes were used to collect feedback from respondents in the field. No prototypes were used in Spain. These prototypes included early-stage physical products, but also simple prototypes like sketches, photos, and videos. When prototypes were used, they were carried around by the researchers and became the center of the discussion. Respondents would handle and/or use the prototypes, they would give feedback directly related to the prototypes, and they would suggest improvements based on what they saw.

The results from the L-MH Model show that when prototypes of any kind were used, the researchers were 30.321 ($p < 0.001$) times more likely to collect information coded as medium or high usefulness than when no prototypes were used. The M-H Model shows that when prototypes were used, the researchers were 7.794 ($p < 0.001$) times more likely to collect highly useful information than when no prototypes were used. It is intuitive that prototypes would facilitate the collection of information coded as medium or high usefulness, but the extent of the influence prototypes had in this study was surprising. This indicates that prototypes are not just a good idea; they should be an integral part of the design ethnography. While it often takes significant effort and resources to either bring prototypes into the community or to build them in the community, this effort is worthwhile because of the usefulness of information it is possible to collect with the prototypes.

Design teams should use prototypes, even simple ones like sketches and mock-ups, as often as possible to facilitate the collection of more highly useful information.

5.7 Need statements

While interacting with respondents, the researchers found that some respondents would state needs explicitly while others stated needs implicitly. The results of the L-MH Model show that needs stated explicitly are 1.747 ($p = 0.011$) times more likely to be coded as medium or high usefulness than needs stated implicitly. The M-H Model shows that needs stated explicitly were 4.925 ($p < 0.001$) times more likely to be highly useful than needs stated implicitly.

While both explicit and implicit needs can be useful in making product design decisions, the results show that, for this data set, explicit need statements were more likely to be coded as medium or high usefulness. The two factors that seem to have affected the way a need was stated are prototypes and gender. With prototypes, both the researcher and respondent are looking at a physical object so it is more natural for the respondent to state needs explicitly.

As shown in Table 10, women were significantly more likely to state their needs explicitly. These explicit needs were coded as higher usefulness, which is another reason design teams should seek out female respondents as they conduct their ethnographic studies.

6 Conclusions

This paper reported on an experiment using design ethnography as a tool for helping design teams understand their developing world customers and context. The results of this study are particularly valuable when designers from developed communities are designing products in these markets. Designers from the developed world have very different life experiences than those living in poverty and are typically unfamiliar with the language, culture, and context of the place where the product they are designing will be used. As a result, their intuition is less reliable for making design decisions about products used in these communities (Allen et al. 2017; Chen et al. 2003; Ramachandran et al. 2007; Jagtap et al. 2014; Viswanathan and Sridharan 2012) and information about customer needs collected through ethnographic activities becomes particularly valuable.

This study includes information collected in four developing communities on four continents. Each location provided different situations that allowed us to quantify the influence of several predictors on the researchers' ability to collect useful information for making product design decisions. Information collected by researchers during the field studies was coded and several statistical analyses were performed. The predictors that yielded meaningful results include cultural familiarity, language fluency, ethnographic

Table 10 Number of excerpts in each need statement category by gender group

	Women	Men	Mixed gender group	Gender not applicable
Non-need statement	1029	1372	426	1454
Implicit need statement	519	542	151	157
Explicit need statement	109	105	174	12

activity used, information source type, gender and age of the respondents, use of prototypes, and type of need statements. Some of the results are intuitive, but all results are quantified using odds ratios which allows us to clearly identify the impact of one predictor over another for this data set (Hilbe 2009).

The results show that cultural familiarity and language fluency have a significant impact on the researchers ability to collect useful information. When design teams are doing ethnographic studies where a problem area has not yet been identified, the results show it can be advantageous to choose a translator because the translator may be able to filter out the bulk of the less useful information and provide the team with the pieces of information that are most pertinent to their design decisions. We believe that this will generate the best results when the translator is given some training in the design process and has a clear understanding of what the design team is trying to learn through their questions.

On the other hand, when a problem area has been specified, the results indicate that design teams should choose projects where they have both cultural familiarity and language fluency as this is the condition that is 12.751 times more likely to lead to highly useful information than with community partners only. When this is not possible, design teams should prioritize projects where they are fluent in the local language, as this makes them 5.734 times more likely to collect highly useful information than community partners alone. Language fluency was shown to have a greater impact than cultural familiarity which indicates that being able to communicate directly with respondents facilitates the collection of highly useful information for product design decisions.

Design teams can use these results to strategically select projects based on their cultural familiarity and language fluency. They can also use these results to strategically form a design team that will give them a higher likelihood of collecting useful information during their ethnographic studies. In practice, there are many other factors that also influence the selection of projects and teams (Nellore and Balachandra 2001; Valkenburg and Dorst 1998). In cases where conditions are not ideal, these results can help the team set expectations and optimize their ethnographic activities for whichever condition they are working in. In all conditions, design teams will be more effective at collecting useful information as they invest in strong partnerships in the community to help facilitate their ethnographic activities (Spinuzzi 2005).

This data set showed that conducting interviews was up to 40.021 times more likely to yield useful information for making design decisions than conducting other ethnographic activities. The researchers also found that this was the most convenient way to collect information because it required the least time and effort from respondents. As design teams plan their field studies, they should note that a variety of ethnographic activities will provide a variety of information that may not be possible to collect with one activity type alone (Creswell and Poth 2017).

Once the design team is in the field, they should consider the sources they choose to engage with (Barab et al. 2004). This study shows that primary sources are 1.516 times more likely than secondary sources to provide highly useful information, indicating that speaking with people directly about their own experiences should be a priority for the design team. The results also show that primary and secondary sources are both more likely to provide information that is of medium or high usefulness than researchers' notes. While these notes help the design team synthesize the information they have collected and make conscious decisions about which activities to pursue and which questions to answer next, interacting with people from the location as much as possible will lead to information of higher usefulness (Blomberg et al. 1993).

Fig. 1 Researcher collecting feedback about a prototype from a local farmer in Brazil

Fig. 2 Rubble from a home destroyed by city officials in Spain

Fig. 3 Researchers conducting interviews through a translator in India

Fig. 4 Researchers conducting interviews in a hospital setting in Rwanda

Another finding was that gender has an impact on the usefulness of the information collected during a design ethnography. This data set showed that women alone were 1.778 times more likely to provide highly useful information than men alone. Women are also more impacted by poverty alleviation efforts (Mattson and Wood 2014) and are likely to be the users of the products being designed (Wignaraja et al. 1990). Because engineering is typically a male-dominated field (Eccles 2007), design teams working on products for resource-poor individuals are typically male-dominated. Developing communities are also typically more traditional, formal, and patriarchal which further limits access to female respondents (The Field Guide to Human-Centered Design 2015; Chikweche and Fletcher 2012). Including female designers on the design team can facilitate increased access to female respondents as it may be more culturally appropriate to have female respondents when women are conducting the ethnographic activities (The Field Guide to Human-Centered Design 2015; Warren 1988). Design teams should collect information from respondents of both genders (LeCompte and Schensul 1999) but the researchers in this study found that it took more conscious effort and planning to collect information from female respondents. Because women are more likely to give highly useful information, the team should put in the extra effort that may be required to ensure an appropriate gender balance in their group of respondents.

The results of this study also indicate that age had an influence on the usefulness of the information collected. Middle aged respondents were up to 1.476 times more likely to give useful information than other age groups. Design teams should seek a balanced group of respondents to ensure a broad range of perspectives on the problem

Table 11 Results from Additional Models 1 and 2

Predictor 1	Compared to Predictor 2	p value	Odds ratio	95% confidence interval	
				Lower limit	Upper limit
Additional Model 1					
India	Spain	< 0.001	9.514	7.105	12.741
Brazil	Spain	< 0.001	2.627	1.951	3.536
Rwanda	Spain	< 0.001	14.181	10.585	19.001
Rwanda	India	< 0.001	1.491	1.260	1.764
India	Brazil	< 0.001	3.622	2.929	4.479
Rwanda	Brazil	< 0.001	5.399	4.342	6.712
Additional Model 2					
Brazil	India	< 0.001	10.001	6.802	14.706
Rwanda	India	< 0.001	8.006	5.699	11.248
Brazil	Rwanda	0.231	Not statistically significant		

These show the L-MH Model and M-H Model, respectively, when the condition predictor was replaced with the country predictor. The predictor in the first column is being compared to the predictor in the second column. For example, the first row is interpreted as "information collected in India is 9.514 ($p < 0.001$) times more likely to be of medium or high usefulness than information collected in Spain"

Table 12 Results from Additional Models 3–6

Predictor 1	Compared to Predictor 2	*p* value	Odds ratio	95% confidence Interval	
				Lower limit	Upper limit
Additional Model 3					
Community partners only	Language fluency and community partners	< 0.001	3.403	2.339	4.950
Community partners only	Cultural familiarity, language fluency, and community partners	< 0.001	6.043	3.701	9.868
Language fluency and community partners	Cultural familiarity, language fluency, and community partners	0.005	1.776	1.195	2.640
India	Spain	< 0.001	4.142	2.856	6.007
Spain	Brazil	0.055	Not Statistically Significant		
India	Brazil	< 0.001	6.142	3.885	9.712
Additional Model 4					
Community partners only	Language fluency and community partners	Insufficient number of excerpts			
Community partners only	Cultural familiarity, language fluency, and community partners	Insufficient number of excerpts			
Language fluency and community partners	Cultural familiarity, language fluency, and community partners	Insufficient number of excerpts			
Brazil	India	Insufficient number of excerpts			
India	Rwanda	Insufficient number of excerpts			
Rwanda	Brazil	Insufficient number of excerpts			
Additional Model 5					
Language fluency and community partners	Community partners only	< 0.001	1.588	1.258	2.003
Cultural familiarity, language fluency, and community partners	Community partners only	0.001	1.695	1.229	2.339
Cultural familiarity, language fluency, and community partners	Language fluency and community partners	0.654	Not statistically significant		
Brazil	India	0.056	Not statistically significant		
Rwanda	India	0.158	Not statistically significant		
Brazil	Rwanda	0.348	Not statistically significant		
Additional Model 6					
Language fluency and community partners	Community partners only	< 0.001	5.734	3.898	8.436
Cultural familiarity, language fluency, and community partners	Community partners only	< 0.001	12.751	8.265	19.672
Cultural familiarity, language fluency, and community partners	Language fluency and community partners	< 0.001	2.224	1.541	3.208
Brazil	India	< 0.001	13.220	8.576	20.380
Rwanda	India	< 0.001	7.750	5.238	11.466
Brazil	Rwanda	0.006	1.706	1.162	2.504

This table lists results for each model with either the condition or country predictor included. The predictor in the first column is being compared to the predictor in the second column. For example, the first row is interpreted as "information collected in the community partners only condition is 3.403 ($p < 0.001$) times more likely to be of medium or high usefulness than information collected in the language fluency and community partners condition"

they are trying to solve (Creswell and Poth 2017) while keeping in mind that they will likely get the most useful information from middle aged respondents.

Our study showed that using prototypes to discuss possible solutions to problems increased the likelihood of collecting highly useful information dramatically (31.321 times). It is intuitive that when a community member can see a product, they are more likely to be able to say whether it meets their needs or not but the magnitude of the impact prototypes have is surprising. Design teams should not underestimate the usefulness of even simple prototypes. Sketches, photos, and videos provided researchers in this study significant and useful feedback without requiring them to build or import expensive, high-fidelity prototypes. Novice designers should be particularly conscientious in their use of prototypes (Deininger et al. 2017).

Needs statements that were stated explicitly were up to 4.925 times times more likely to provide highly useful information than those stated implicitly. Prototypes can help facilitate explicit need statements (The Field Guide to Human-Centered Design 2015). Women were more likely to provide needs stated explicitly, which is an additional reason for the team to seek out female respondents for their ethnographic activities.

Overall, the results of this study can help design teams as they plan their own ethnographic studies and activities. These four communities represent a small though broad sample that serves as a starting point for exploring the relationships between cultural familiarity, language fluency, partners in the community, as well as other factors like gender, age, information source type, etc. It would take an incredible amount of resources to collect enough information to draw conclusions that would be universally applicable. Increasing the sample size to include a wider variety of locations, ethnographic activities, and more respondents would lead to results that apply more generally but we believe this sample size is large and diverse enough to provide useful insight for designers planning design ethnographies.

There are several limitations to the work described here. One is that the stage of product development the design team was in when the information was collected was not coded for. For example, some excerpts would be highly useful during an opportunity discovery stage and less useful in a system engineering stage and this was not explicitly accounted for with the codes used for this study. The study also omitted several other variables that could have led to great insight for design teams, such as income of the respondent, literacy level of the respondent, physical infrastructure in the community, social networks in the community, and many others. The study presented here describes only a small sub-set of the variables that could possibly affect the design teams ability to collect useful information for product design. Another limitation is that the type of prototype was not coded for. This analysis made no distinction between sketches, videos, mock-ups, and full-scale prototypes but this level of detail could lead to additional insight for design teams.

Future work could also include refining the definitions of some of the predictors used in this study. For example, how fluent in the local language does a design team need to be to gain the benefits of interacting directly with respondents? How much time spent in a location previous to the ethnographic study is needed for the design team to gain the benefits of cultural familiarity during their study? Which other ethnographic methods could be used to collect information useful for product design? Researchers could also explore the use of visual information, such as photos and videos, or the development of new ethnographic methods to collect more explicit need statements from both men and women. Another interesting predictor that could be analyzed is time spent during the ethnographic study. Each of the field trips included in this study were a different length of time. Some guidelines for the optimal amount of time for a given set of predictors would be of great value to design teams (Figs. 1, 2, 3, 4; Tables 11, 12).

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