



UC Berkeley School of Information

**CONTEXTUAL DESIGN IN THE DEVELOPING WORLD**  
*CASE STUDY OF A TELEMEDICINE SYSTEM IN GHANA*

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## **ABSTRACT**

The following paper outlines the design process, results, and observations used in developing a system for remote consultation between doctors in Ghana and doctors abroad. The primary users fall into three distinct categories: general practitioners from the district hospitals within Ghana who would typically be seeking a consultation, specialists at the two teaching hospitals within Ghana, and specialists working in the United States. While this project draws from rapid ethnography within Ghana in the winter of 2005-2006, and while the interface design for American doctors followed a user-centered approach, we focus on our contextual inquiry within Ghana. We present detailed observations from our field visits and flesh out key findings from select work models that we developed. Finally, we illustrate some of the key features in our prototype system.

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## INTRODUCTION

REACH, a system for Remote Asynchronous Communication for Healthcare in Ghana, is an ongoing project that arises out of a collaboration between the School of Information at the University of California, Berkeley, and Intel Research.

This project is in direct response to the shortage of medical expertise in Ghana, West Africa, and in particular the shortage of specialist knowledge. In a country of 20 million people, there is a huge divide in access to qualified healthcare professionals. In the urban South, for example, there is at least one doctor for every 5000 people, while, for example, the region of Wa in the rural North averages 1 doctor for every 60 000.<sup>1</sup> Moreover, given that the official language of Ghana is English and that the quality of medical education is the envy of much of West Africa, it is no surprise that emigration to the English-speaking Western world is a huge problem. This trend has been evident over the past 30 years, to the extent that 30 out of 100 practicing Ghanaian doctors are working in the US or the Commonwealth.<sup>2</sup> Other studies have shown that more than 60% of the doctors trained in Ghana over a 10 year period ended up leaving the country, to the extent that today there are 3 practicing urologists, 4 neurologists, and a handful of neurosurgeons serving a population half the size of California.<sup>3,4</sup>

The task that we are presented with today is how to use modern communication technologies to harness the incredible wealth of specialist knowledge among the Diaspora for the benefit of those left behind in Ghana. The focus of this paper is to report on our observations and models, as they inform the design of our final prototype. Note that this paper assumes an in-depth understanding of the design literature, and hence does not explain the details of specific methodologies. For references to such methodologies, see Appendix A.

## METHODOLOGY

The design process can be broken up into three distinct phases, detailed below. See Appendix A for an overview of different design methodologies as well as a justification for why the overarching strategy for this design draws so strongly from contextual inquiry. However, different techniques became appropriate at different phases in the design cycle. Our methodology can be broken down into three relatively discrete phases. The first was an initial field visit to gain a rapid understanding of the context and culture. The second followed standard user interface design practice for doctors in America while the third adopted a more in-depth, contextual design strategy for drawing richer data about needs and constraints from doctors in Ghana.

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<sup>1</sup> WHO — World Health Statistics Database 2005, 2005.

<sup>2</sup> F. Mullan. The Metrics of Physician Brain Drain. New England Journal of Medicine, 353:1810–1818, Oct 2005.

<sup>3</sup> Dovlo, D., Nyonator, F. “Migration of Graduates of the University of Ghana Medical School: A Preliminary

Rapid Appraisal”. Human Resources for Health Development Journal (HRDJ) 3(1), January - April 1999.

<sup>4</sup> Personal interview, Dr. Josey Gharty, Trust Hospital, Accra, Ghana.

# **FIELDWORK**

## **Phase 1: Rapid Ethnography, Ghana, December 2005- January 2006**

Phase 1 consisted of semi-structured interviews, participant observation, and focus groups over a period of six weeks in nine institutions across Ghana (Figure 1).

- Duration of Visit 6 weeks
- Number of Institutions Surveyed 6 hospitals, 3 clinics
- Number of Interviews 12 doctors, 1 administrator, 2 nurses, 1 clerk
- Methodology rapid ethnography
- Purpose high-level study of user environment and needs



**Figure 1: Phase 1 Fieldwork Sites**

Bolgatanga Regional Hospital and Wa Regional Hospital are two government hospitals in the north of Ghana chosen to represent less populated, more under-developed, and more impoverished Northern region of Ghana. The large hospitals and small polyclinics in Accra and Kumasi (Trust Hospital, the Korle bu Polyclinic, and Korle bu Teaching Hospital) were also chosen as study sites since they represented the logical and practical hubs of medical education and coordination. Visits included site tours and surveys of site ICT infrastructure.

The interview guide for the doctors centered on their perspectives on health care practice in Ghana, focusing on existing computing infrastructure and key healthcare needs. The interviews also explored their opinions on whether and how telemedicine could play a role in meeting those needs.

Participant observation was used to capture medical information exchange processes in situ. Two doctors were shadowed in outpatient clinics, sitting in as an observer and following them on their rounds as they checked on the inpatients in the wards. During these visits, copies of all relevant information artifacts were collected, such as the paper forms used to maintain records and exchange information.

One of the key inspirations for our design was the case of Yaa and Akosua, a young mother and her child who had traveled a great distance to come to Trust Hospital for treatment (Names have been changed for patient protection). Akosua had a severe case of hydrocephalus that was highly advanced, and yet exhibited excellent responsiveness and alertness. Their doctor at Trust Hospital was a general practitioner who felt that she knew the appropriate procedure, but she had never dealt with a case like this before and wanted a second opinion. Neurosurgeons were available at Korle Bu hospital, however the main phone lines are rarely answered and there is no official venue through which such a simple telephone consultation could occur. After days of trying to contact a specialist, the doctor eventually contacted a friend of a friend of a friend at Korle Bu, who was able to provide a consultation over his cell phone that allowed the doctor to proceed with the operation. If we could only design a system that would unify, organize, and streamline these informal communication mechanisms, perhaps the specialist could have provided an accurate diagnosis and treatment plan earlier. As it was, it was too late for Akosua, and she passed away of complications a few days later.



**Figure 2: Yaa and Akosua**

## **Key Findings**

Some of the themes that arose from this fieldwork included:

- 1) Failures in the referral infrastructure by which patient information is transmitted from one doctor to another.
- 2) Expediency of patient care, wherein physical interaction between doctor and patient was rarely required.
- 3) Conception of telemedicine as an expensive, high-overhead process requiring dedicated equipment prone to failure.
- 4) A lack of human resources due to the exodus of qualified personnel to other countries.

There is a sense in which each theme can be glossed or trivialized – reduced to yet another well-known issue in countries that have problems with emigration of professional workers. What will be relevant to our design implications are the details of the situations faced by the participants and their conscious awareness that ICTs offer possibilities in ameliorating them.

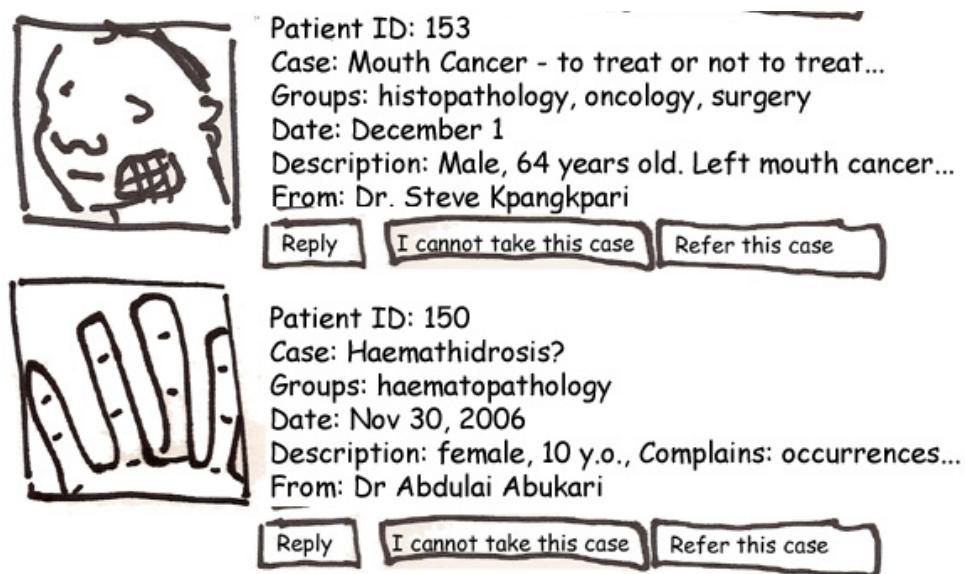
As a result of the communications breakdown between hospitals and between doctors, patients come in with insufficient and sometimes falsified referral information, leading to confusion and sometimes inaccurate diagnoses. Other patients travel long distances away from their families, only to find out that their condition is not treatable. In addition, doctors working with the patients are unable to discuss patient history, and therefore are unable to leverage each other's knowledge in coming up with better diagnoses. Secondly, the migration of doctors overseas means that important intellectual capital is less accessible. The Ghanaian doctors feel overworked, underpaid, and unappreciated. We seek to address this issue by helping them to better leverage resources that are untapped due to inaccessibility. The Ghanaian diasporic doctors form a group motivated to supplement the intellectual resources strained by their departure.

## **Phase 2: User Interface Design for Doctors in America, Fall 2006**

In phase 2, we made contact with a variety of Ghanaian doctors located across North America and conducted one in-person and 5 telephone interviews.

- |  |  |
|--|--|
| <ul style="list-style-type: none"><li>• Number of Interviews</li><li>• Methodology</li><li>• Purpose</li></ul> | 4 specialists, 2 general practitioners<br>semi-structured interviews,<br>paper prototype iterations<br>user interface design with American doctors |
|--|--|

Recognizing that our system aims to connect two very distinct, if related, communities, phase 2 was tackled as a completely independent and parallel design process, involving its own needs assessments and paper prototyping iterations. However, because we had a significantly greater understanding of the environment and lifestyles of these users, we did not perform as rigorous an analysis of the user's context.



**Figure 3: First Paper Prototype – Case-Centric Display**

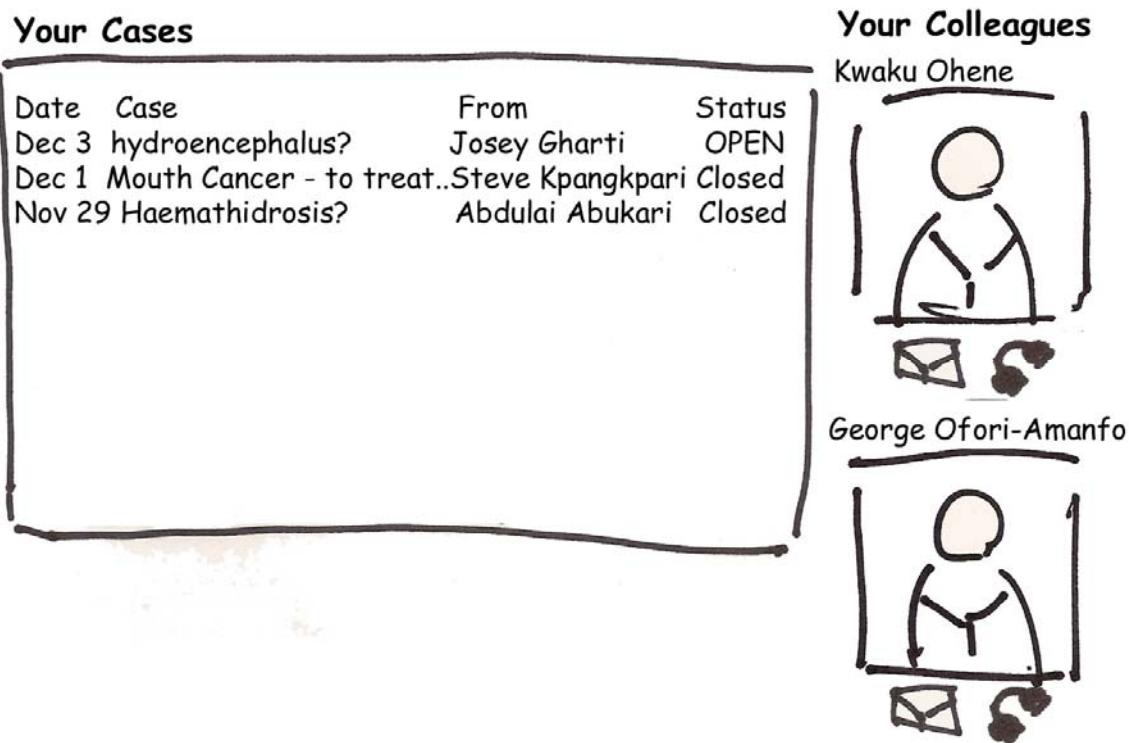


Figure 4: First Paper Prototype – Message-Centric Interface

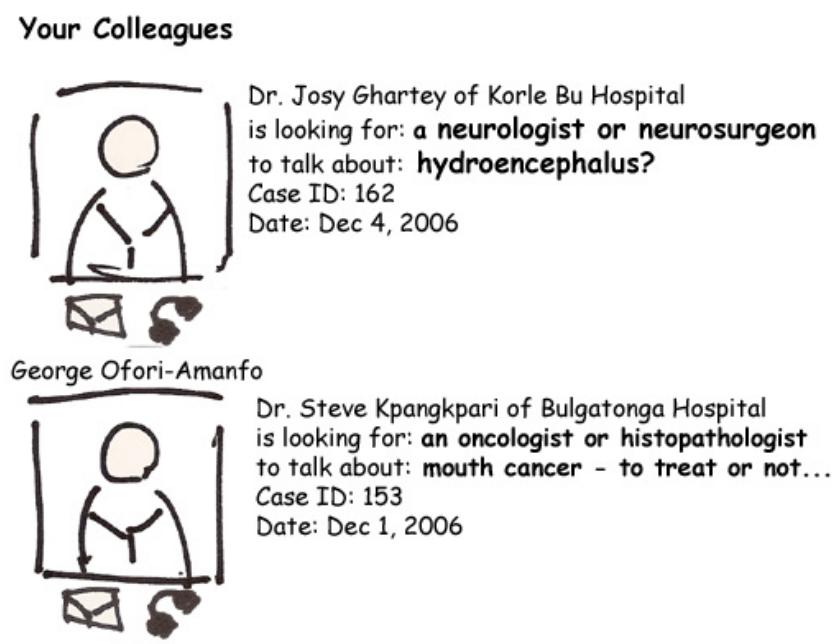


Figure 5: First Paper Prototype – Doctor-Centric Interface

## **Key Findings**

In this phase, our design was pared down from a much richer feature set to a cleaner, more task-oriented interface. We interviewed doctors on the subject of their current consultation practices and also presented them with paper prototypes along three general themes:

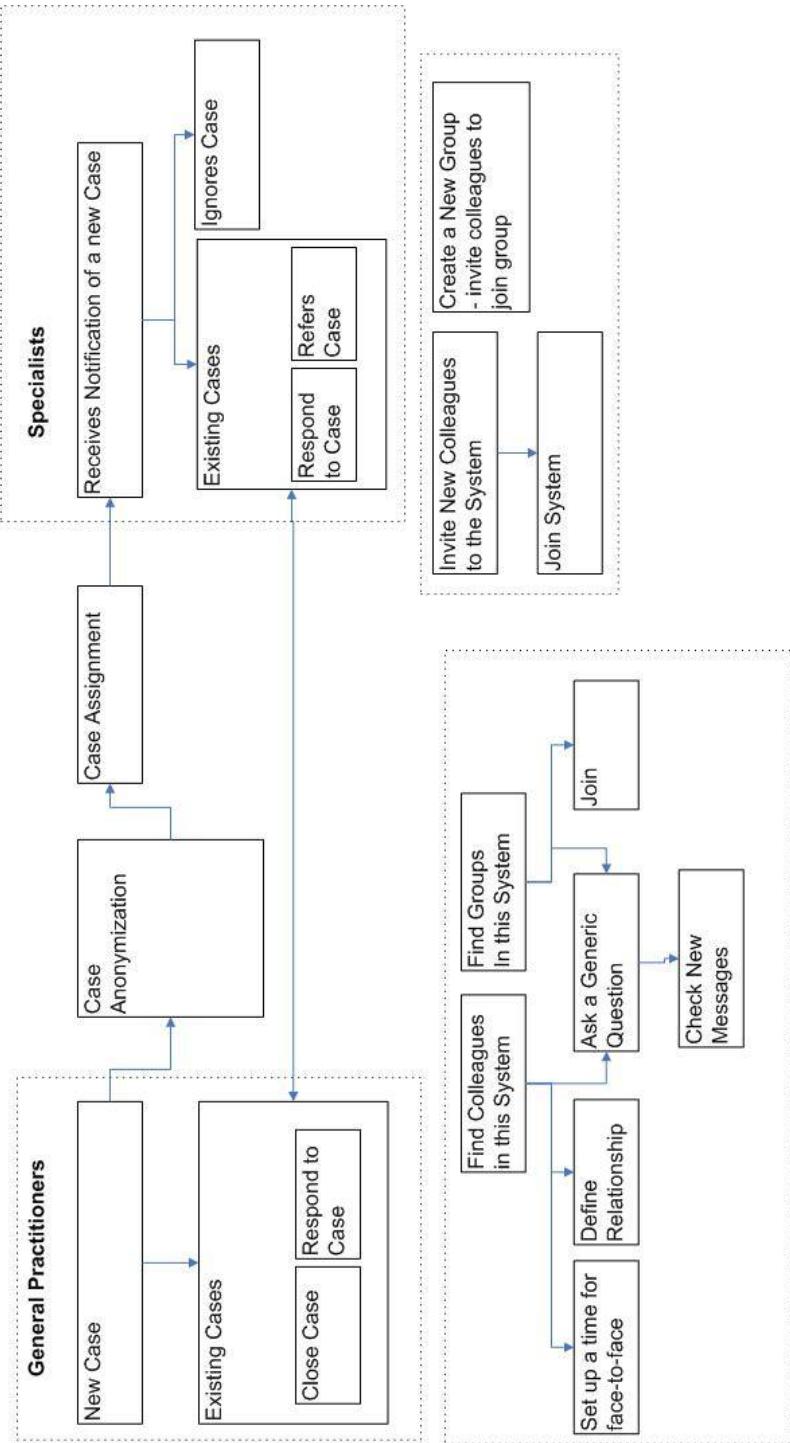
- Message-centric displays
- Doctor-centric displays
- Case-centric displays

It quickly became apparent, through direct statements on the subject but also indirect cues in the language and behaviour of the doctors that there is a layer of professionalism that mediates any doctor-patient relationship, to the extent that patient relationships are not a viable, personal incentive for using the system. That is, the doctors we interviewed saw their work in patient consultation as a service to the community, but were not interested in peripheral information about that patient apart from what related to their medical history, even if the patient offered that data voluntarily. However, participants did express a great deal of interest in rich information about other doctors in the system, purportedly so they could make an informed decision on where to refer a case. However, the amount and type of information requested varied greatly, from just their specialization to rich histories of where they have worked and with whom.

Moreover, in recalling their experiences practicing medicine both in the US and in Ghana, the participants conveyed a sense of the urgency and task-oriented nature of medical work, which led us away from a more informal, social model to a task-oriented model that would fit well within a doctor's busy life, both personal and professional. To this end, *we moved towards a hybrid of the message-centric and case-centric display.*

A second key question that arose in this time was how *case assignment* should work. Opinions varied in conjunction with the amount of investment doctors felt within the system, from an obligatory, on-call model to a very open-ended, group-browsing mechanism. These questions remained unresolved at the close of this phase of fieldwork, so we placed an added emphasis on it in Phase 3.

- Overarching Goals:**
1. second opinions (to treat or not to treat? What else can I try?)
  2. referrals (this patient is going to show up at your door in a week)
  3. connect with an old colleague (how have you been? How is America?)
  4. share informal/catch-all questions/informations (What kind of syringe should I buy?)



**Figure 6: User Environment Design**

### **Phase 3: Contextual Inquiry, Ghana, Winter 2006-2007**

In phase 3 we conducted a much more targeted needs assessment and worked through iterations of paper prototypes over 5 weeks across 15 public hospitals and several clinics in Ghana using semi-structured interviews.

- |                                   |  |
|-----------------------------------|--|
| • Duration of Visit               | 5 weeks                                |
| • Number of Institutions Surveyed | 15 hospitals, 3 clinics                |
| • Number of Interviews            | 30 doctors, 5 administrators, 4 nurses |
| • Methodology                     | contextual inquiry                     |
| • Purpose                         | user modeling and design refinement    |

These interviews continued the previous survey of technology baselines and healthcare needs, but also provided much more targeted discussion of the application under development. We explored themes of remote consultation, intra-hospital communication, relationships overseas, and walkthroughs of low-fidelity prototypes.



**Figure 7: Phase 3 Fieldwork Sites**

In analyzing the data collected, we applied coding, clustering and category creation techniques from grounded theory.<sup>5</sup> The analytic process took into account previous

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<sup>5</sup> A. Strauss and J. M. Corbin. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory (2nd Ed.). SAGE, 1998.

background research as well as the interviews, observations and documents collected during the fieldwork. The next subsection describes the resulting findings.

Create a New Case		ReACH
<p>Case: Mouth Cancer: To Treat or Not To Treat Patient ID: 324 Groups: <input type="checkbox"/> Neurologists <input type="checkbox"/> Orthopaedic Surgeon <input type="checkbox"/> Obstetrics/Gynecology <a href="#">More...</a></p>		<p>Who would you like to consult?</p> <p><input type="checkbox"/> Dr. Peter Woolwich  <input type="checkbox"/> Dr. Edward Norton  <input type="checkbox"/> Dr. James McPhain </p> <p><a href="#">More Specialists...</a></p>
<p>Attach An Image</p>		

**Figure 8: Excel Prototype of the Case Creation Screen**

**YOU HAVE RECEIVED A NEW CASE!**

ReACH

**Case:** Mouth Cancer: To Treat or Not To Treat  
**Patient ID:** 153  
**Groups:** histopathology, oncology, surgery  
**Date:** 09:15

Male 63yrs old. Left mouth cancer confirmed. Should he be treated with trial of chemotherapy?

**Picture 1**      **Picture 2**

POSTED BY  
Dr. James Burrell, Ho



[View Profile](#)

[Reply](#)    [I cannot take this case](#)    [Refer this case to someone else](#)

**Figure 9: Excel Prototype of the Case View Screen**

## **WORK MODELS**

# THE PHYSICAL MODEL

## *Limited IT Infrastructure*

The following table provides an overview of the IT infrastructure in the hospitals that we surveyed.

**Table 1: Overview of IT Infrastructures within Public Hospitals in Ghana**

	Number of Doctors	Number of Computers	Intranet Connectivity	Internet Connectivity
Korle Bu Hospital	>50	>20	Partial	DSL
Ho Regional Hospital	16	~4	Complete	None
Ho Municipal Hospital	16	None	None	None
Kasseh	3	5	Wireless	VSAT
Tema	~50	10	Wired	None
Cape Coast District	3	~5	Wired	None
Cape Coast Regional	17	~10	Wired	None
Takoradi District	2	None	Wired	None
Takoradi Regional	~20	5	Wired	None
Winneba	3	3	Wired	None
Komfe Anoyke (KATH)	>50	>20	Wired	VSAT
Tamale	~20	~4	None	Dial-up
West Gonja Hospital	2	2	None	VSAT
Bolgatonga	2	3	Wired	None
Kassenekane (Navrongo)	4	2	None	None
Akosombo	1	3	Wired	VSAT
Wa Regional	4	2	None	None
Berekum Holy Family	2	1	None	None
Navrongo Research	2	>15	Wired	VSAT
Sunyani	5	8	Wired	Dial-up

However, among 35 doctors that were interviewed, 30 indicated that they did indeed have an email address which they would check from an internet café on weekends, while 7 owned laptops and had internet connectivity at home.

However, one very interesting trend was that **every single doctor interviewed had at least one cell phone**. In fact, the majority had 3 or 4, in order to optimize their chances that they could be reached on one of Ghana's major networks, and many remarked that

they used text messaging much more frequently than emails. Clearly, leveraging the cell phone connectivity is not only key, it is almost essential to creating a system that will be usable by all the doctors in the target market.

### ***Intermittent Power and Connectivity***

Another feature of this environment that became clear after only a few days in situ was that most of these institutions were subject to power surges, outages, and harsh environmental conditions that could seriously damage more electronic equipment. This was not only a consideration in our rural sites, but even when we were guests in the home of a colleague living in one of Accra's richest neighbourhood. In the capital city, for example, power rationing ensured that different neighbourhoods only received power four out of every five nights, and during the dry season when hydroelectric power was less readily available, this can decrease to only one or two days of power at a time. While the hospitals all have generators that supply them during these outages, it often takes several minutes for the alternative power supply to come into effect.

## **THE ARTIFACT MODEL**

Several paper artifacts proved instrumental in understanding the type and structure of data flow in these organizations, particularly since the information was so specialized and structured.

Referral notes collected from the United Nations Clinic, Korle Bu, Winneba, and a few private clinics gave a window into the dynamics of patient referral within Ghana. On such a note, a doctor might transcribe a brief patient history and the treatment given already, as well as why the patient is being referred. The nurse selects the appropriate specialist and institution from a compiled list, calls ahead to notify them of the referral, and then the patient takes the referral to the hospital. This is the ideal scenario, practiced in the well-funded and well-staffed UN Clinic. However, in practice, it rarely works so well.

Another example is the Trust Hospital outpatient clinic, where the doctor sits in a consulting room with a set of medical record files corresponding to the patients waiting outside. In a single two hour session, we observed 22 patient interactions. The consultation was primarily a question and answer session with some purely visual inspection. For each patient, the doctor pulls out the medical file, reviews the existing documentation, and starts asking the patient about the condition faced. The doctor writes down the chief complaints, patient history, and recommended treatment on a new patient record card (see Figure 3), which is filed in the folder and placed in the stack of folders for later processing by the data entry clerk. Prescriptions and lab orders are written and handed to the patient for processing in other locations in the hospital.

MINISTRY OF HEALTH					DATE, DIAGNOSIS CLINICAL HISTORY, TREATMENT, PRESCRIPTION
1st OP No.		Surname			
2nd OP No.		Other Names			
		Address (Home)			
Unit No.		Address (Employer)			
Non-paying	Age	M	F	First Diagnosis	
DATE, DIAGNOSIS CLINICAL HISTORY, TREATMENT, PRESCRIPTION					
1	Ref. No. 12				Patients Record Card Form M. H. 40
					2

**Figure 10: Patient Record Card Form for a Single Visit**

Thus the current mode of use is very much pen-and-paper based, and must occur rapidly, with most patients diagnosed in the span of five minutes. A small number of cases are more involved, but additional time is primarily spent on patient education about their particular condition. This staged entry process seems redundant until there is a power outage - paper-based forms still work in the absence of electricity, while the hospital generators may not have sufficient load to power the computers in addition to critical equipment.

Major failures of this system arise when a patient is referred from one institution to another, wherein they typically receive a “referral note” that they are then responsible for safeguarding until their arrival at the next hospital. Needless to say, such documents are invariable lost or damaged during transit, or even hoarded in case the patient needs a future referral. Participants expressed dissatisfaction with the feedback provided on such cases, or lack thereof, even when specific feedback was requested on the referral form.

We find here an interesting dichotomy behind the kind of unstructured data representation shown in Figure 10 and the way participants responded to initial paper prototypes provided room for such unstructured data. When asked to rate an unstructured form (such as Figure 10) against a much more strict form, participants *universally* chose more structured data, in the belief that such forms would ensure more rigorous, better organized data. In this aspect, the paper forms were not a good indicator of the type of

virtual forms we should be created, since much of the structure in the paper forms was implicit in the way doctors were trained to write referrals.

## THE CULTURAL MODEL

### ***Social Networks***

*“They just left en masse, swallowed up by the US and UK.”* (Dr. V, Accra hospital)

For better or for worse, the Ghanaian community is very small. There are only two teaching hospitals, which historically have had graduating classes of only 50 people or so. What this means is that, in effect, any doctor who has practiced for a few years today will typically already know most of the other doctors in the field. What has become apparent in our field observations over five weeks in Ghana in the winter of 2005-2006 and an additional five weeks in 2006-2007, is that these informal social networks are already being used to fill in the gaps in existing infrastructure, in order to determine patient histories, provide continuing medical education, get second opinions, and transfer patient information between hospitals. It is hoped that tapping into this network will provide a key incentive to adopt this technology and integrate into existing work practices.

### ***Perceptions of the Diaspora***

When solicited to describe their relationships with doctors who had gone overseas, most participants responded with generic, almost trite positive remarks. A small handful, however, about three or four, spoke more frankly of their concerns in being able to draw the interest of Ghanaians abroad, who had clearly left seeking better opportunity. This was an interesting contrast because our colleagues in the United States clearly indicated a strong connection to their homeland, just not strong enough to tie them to that country. In fact, there is a certain pride associated with having chosen to stay within the country despite better work prospects overseas, although this pride is coupled with an understandable concern for the demands of such work.

*“I decided to stay in this country to help, so I will... They don’t have any dental surgeons up there. I cannot go right now for several reasons: 1) my parents are down south here, I take care of them. When I am there, who will take care of them? 2) My wife is here. I’ll do things for my country, but if they force to do it at not the appropriate time... Why can’t we do it at a time when you can be efficient and do it in a good state of work?”* (Dr. V, Accra hospital)



**Figure 11: Focus Group**

## THE FLOW MODEL

### ***Communication and Referral Between Hospitals***

The healthcare system in Ghana is tiered, with primary care delivered through local polyclinics and health centers. There are 92 district hospitals, and 9 regional hospitals, each in principle requiring referrals from hospitals at lower tiers in order to administer care. Severe cases are referred to one of the two teaching hospitals in Accra and Kumasi (Figure 1) where specialists have the equipment and resources to carry out more complicated procedures.

There was an interesting contrast between the informal referrals within hospitals and the formal referrals between hospitals. Within hospitals, cases were seamlessly referred to whichever was the appropriate specialty.

*“If he’s around ... it’s a referral, but you don’t need a ‘referral book.’ You just give them the booklet, this one, and the patient folder. You don’t need to write a proper referral note to the physicians-specialist in this hospital, because he will use the same booklet. And then you give it to the nurse.” (Dr. G, Tema Hospital)*

However, between hospitals, the work flow model simply did not allow for regular consultation.

Do you communicate with other doctor at all?

*Rarely. Occasionally, on an informal basis.*

What do you talk about?

*If there are some difficult situations that you encounter during your practice, then you want to call a colleague.*

What do you know them from?

*Most of them are from school. Since you don't have a specialty, you might call a colleague or a friend in a particular specialty.*

The only time you would call a colleague at another hospital is because you know them?

*Yes*

(Dr. G, Tema Hospital)

How much of this distinction is a result of the inconvenience of contacting a doctor elsewhere and how much is a result of social or institutional norms remains to be seen.

### ***Continuing Medical Education versus Emergency Treatment***

One of the key tensions arising in the fieldwork was the tension between two very distinct needs: one for emergency data transmission and the other for continuing medical education. So one general practitioner writes:

*"My uses for the system would be:*

*Number One: Emergency Referral.*

*Number Two: Emergency Referral.*

*Number Three: Emergency Referral...*

*Number 10.5: second opinions [on hard cases]... General Practitioners do not need to talk among themselves. They will have no more than a year experience in any given specialty. Talking to other general practitioners would not be useful to me..."* (Dr. N, district hospital)

While another one at another hospital states:

*"You can't just keep doing things the same old ways... you always have to be looking for ways to do things better. Often cases can wait. 2 days, 3 days. You just tell the patient to come back whenever the information will be available."* (Dr. K, district hospital)

# **FINAL DESIGN**

## SMS NOTIFICATIONS

Given the universal availability of cell phones in this population alongside the inconvenience of going to a cybercafé, leveraging that cell phone infrastructure became a key component of our design. While the cell phone interface is much too small for reviewing patient, it is yet ideal as a hook to draw users who may not visit the cybercafé regularly into using the system. Indeed, notification of a new case in the system is anticipated to be one of the primary use cases of this system.

Figure 12 illustrates the variable granularity of notification settings available to the user/administrator.

The screenshot shows a web-based application interface for managing email alerts. At the top, there is a navigation bar with links: User list, Account, Preferences, Alerts, and Groups. The 'Groups' link is highlighted. Below the navigation bar, the title 'Email alert settings >> Frempong' is displayed. On the left, a sidebar menu for 'Frempong' includes options like Logout, My Cases, My Colleagues, My Groups, My Account, Preferences, Alerts, Find Other Doctors, and Find Other Groups. Another section for 'Admin' includes Manage My Groups. The main content area is titled 'Email alert settings >> Frempong'. It features a table where groups can be selected to receive notifications for different events. The columns are 'Group', 'Notify me about these events', and 'Options'. The 'Notify me about these events' section has three checkboxes: 'New case', 'New comment on any case', and 'New comment on my case'. The 'Options' section contains two checkboxes: 'Send only a summary once a day (no fulltext report)' and 'Include full case report (HTML email)'. Two groups are listed: 'GPS Foundation' and 'Internal Medicine'. Both groups have all three event checkboxes checked. The 'Options' checkboxes are also checked for both groups. A 'save' button is located at the bottom left of the table. At the very bottom of the page, there is footer information: '© 2000-2005 Intel Research Berkeley (version 2.0.5)', 'you are logged in as Frempong since 0 seconds, last access 0 seconds', and 'script executed in 0.082 seconds, 0.032 seconds for SQL and seconds for XSLT'.

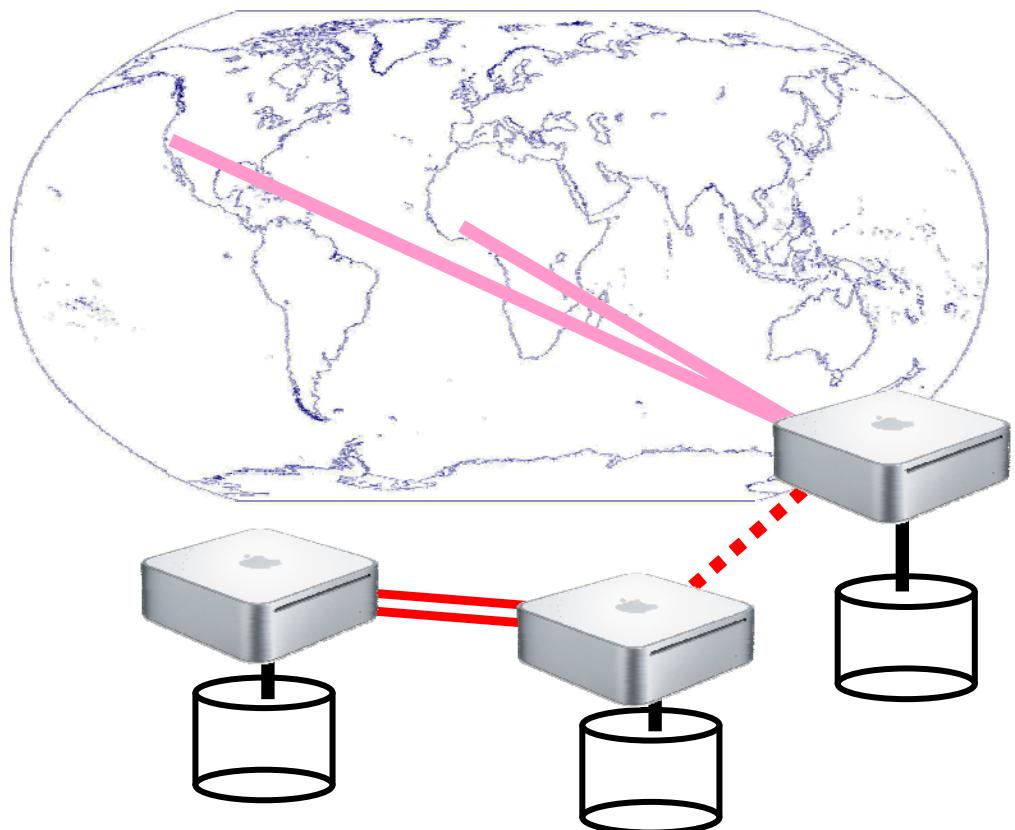
**Figure 12: REACH's SMS Alert Configuration Screenshot**

## **AUTOMATIC RECOVERY AND DELAY-TOLERANT NETWORKING**

Our strategy to address intermittent power and connectivity include automatic system recovery and delay-tolerant networking respectively. We modified the boot mechanism on our servers so that after the system has been powered down unexpectedly, it automatically boots up to its initial state after power returns. This was a simple configuration feature, but essential to making this system robust over multiple power surges/failures.

To address the intermittent connectivity, the system will be designed from the start to make no assumptions about consistent connectivity amongst all its clients. What this means is that each client should be able to operate in complete isolation from any other part of the network, but semantics will be built into the system to avoid conflicts on data updates and writes. This feature will enable the use of delay-tolerant networking technology, which will be used to synchronize the raw data structures between individual clients. However, we will handle application-level conflict resolution.

So, for example, say that a doctor in one hospital appends a comment to one case, while a doctor in another hospital deletes or archives that same case. When those two systems are synchronized, how does the application append a comment to a case that no longer exists? In this case, our solution is to ensure that cases are never deleted, only marked “closed.” Building this application means that we will have to identify and resolve such conflicts in a way understandable and intuitive to the user.



**Figure 13: Delay-Tolerant Networking via Coordination of Distributed Servers**

## SOCIAL NETWORKING

Building upon our observations of how existing work practices leverage informal as well as formal ties in the workplace, and in particular how the small size of the community can blur the lines between professional and personal, we chose to adopt a social networking approach to provide incentives for participation and build trust within the system.

Apart from the usual cabal of features available with most modern social networking sites (such as automatic address updates, profiles, messaging, and directories), our system leverages the social network information to supplement case updates and referrals. This can be seen in the following two features:

### Personal Ownership of Cases

The dashboard sheet (Figure 14) illustrates the first page that appears upon logging into this system. It divides cases up into cases that you created, regarding a local patient, and cases that other people have “given” you.

ID	Case	Local Doctor	Created	Last Reply
10163	Female, 17 y.o., Possible Haemathidrosis	Clem	2007-04-08	2007-04-08
10162	Female, 40 y.o. Seizures	Clem	2007-04-08	2007-04-08
10161	Female, 34 y.o. Unusual chest growth	Clem	2007-04-08	2007-04-08
10158	Male, 70 y.o., Cancer treatment options	Clem	2007-04-08	2007-04-08

ID	Case	Local Doctor	Created	Last Reply
10161	Female, 34 y.o. Unusual chest growth	Josey	2007-04-08	2007-04-08
10158	Male, 70 y.o., Cancer treatment options	Kwaku	2007-04-08	2007-04-08

Figure 14: Individual Case Ownership and Updates on Colleagues

## Individual Assignment of Cases

The notify sheet (Figure 15) illustrates how doctors have the option of giving cases to either individuals or groups. This duality arises from the fact that we want to make social connections an accessible resource while providing the option of tapping into people who may be currently unknown but are part of a larger group or context through which they can *become* known. So, for example, other social networking applications provide the ability to “hook up” with existing friends while also providing the context to make new ones.

- a) Groups will be displayed from a limited list of available groups.
- b) “Other colleagues” will highlight personal contacts (created explicitly) of the correct specialization.

The screenshot shows a web-based application interface for notifying medical cases. On the left, a sidebar includes a language dropdown set to English, a 'Your Account' section with links to Home, Find case, presentations, and a 'Test1' user profile (Logout, My Groups, My account, Preferences, Alerts). The main content area has a blue header bar. Below it, a section titled 'Select a doctor or group of doctors to notify:' contains three columns. The first column, 'Doctors at your Referral Hospital', lists 'Frank Adgemorzi Adgemorzi Bolgatanga Regional Hospital' with a photo, phone number 123 456, and a 'Request Consultation' button. The second column, 'Your Colleagues', lists 'Asante Damquah Cape Coast Regional Hospital' with a photo, phone number 123 456, and a 'Request Consultation' button. The third column, 'Groups', lists 'Ghana College of Physicians and Surgeons USA' with a logo and a 'Request Consultation' button. At the bottom, copyright information reads '© 2000-2005 Intel Research Berkeley (version 2.0.5)' and a log message says 'you are logged in as Test1 since 7 seconds, last access 2 seconds script executed in 0.092 seconds, 0.006 seconds for SQL and 0.020 seconds for XSLT'.

Figure 15: Notification Screen

## HIGHLY STRUCTURED FORMS

In comparison with some of early prototypes (see Figure 8), the final system makes use of highly-structured forms, namely the case creation form in Figure 16. As noted in the section on the Artifact Model, while the paper forms for referrals are themselves quite sparse, the information within patient records is much more structured. Moreover, even the unstructured forms are used in a very structured way, by doctors who have been trained with various mnemonics about how to present patient information fully and in an organized manner. To that end, participants universally advocated more structure in patient data entry forms. These forms are stored in a flexible format using XML and XSL, and can be easily modified to support evolving data needs.

The figure shows a screenshot of a web-based application interface. On the left, there is a vertical sidebar with a dark blue background. It contains a 'Language' section with a dropdown menu set to 'English'. Below this are sections for 'Your Account' (with links to Home, Find case, presentations), 'Clem' (Logout, My Groups, My account, Preferences, Alerts), and 'Admin' (Find Other Doctors, My Groups). At the bottom of the sidebar is a large blue area. The main content area has a white background. At the top right, there is a 'Remote Consultation Request Form' header with a 'Home' icon and a 'save' button. Below the header, there are fields for 'Title' (text input), 'Age' (text input), and 'Gender' (radio buttons for Male and Female). There are also two groups of radio buttons: 'What specific information are you looking for?' (Diagnosis, Additional Exams/Tests, Treatment, Referral, Other) and 'From what specialization?' (Surgery, Internal Medicine, Obstetrics/Gynecology, Pediatrics, Other). Below these are sections for 'Patient Complaints\*' (large text area), 'History\*' (text area), and a 'Request Consultation' button. Under 'Additional Information', there are five sections with text areas: 'Initial Diagnosis\*' (text area), 'Treatment So Far' (text area), 'Clinical/Lab Findings' (text area), 'Investigations' (text area), and 'Other Comments' (text area). At the bottom, there is a note about 'images' and a 'visibility' section with options for hidden or public visibility. Finally, there is another 'Request Consultation' button at the bottom.

Figure 16: Rich Case Creation Form

## INTEGRATION WITH REFERRAL INFRASTRUCTURE

In order to match existing mental models of work structure and flow, this system will be designed to support referrals between hospitals as well as remote consultation. The expectation is that doctors can quickly understand the referral nature of this software while slowly learning to tap into the diasporic expertise.

The application will be designed to support both private and public cases. Private cases serve as a reliable data transfer medium between two hospitals, typically for referral, while public cases lend themselves towards open consultation among a community of online doctors. Returning to Figure 15 (reproduced below), we see that the notify screen always includes the doctor that would naturally fall next in the traditional referral infrastructure. Our hope is that by presenting the classic referral doctor, colleagues, and professional groups side-by-side in the manner, we will be able to gather rich user data on how and when participants choose to notify their referral doctor versus any of the colleagues or professional organizations.

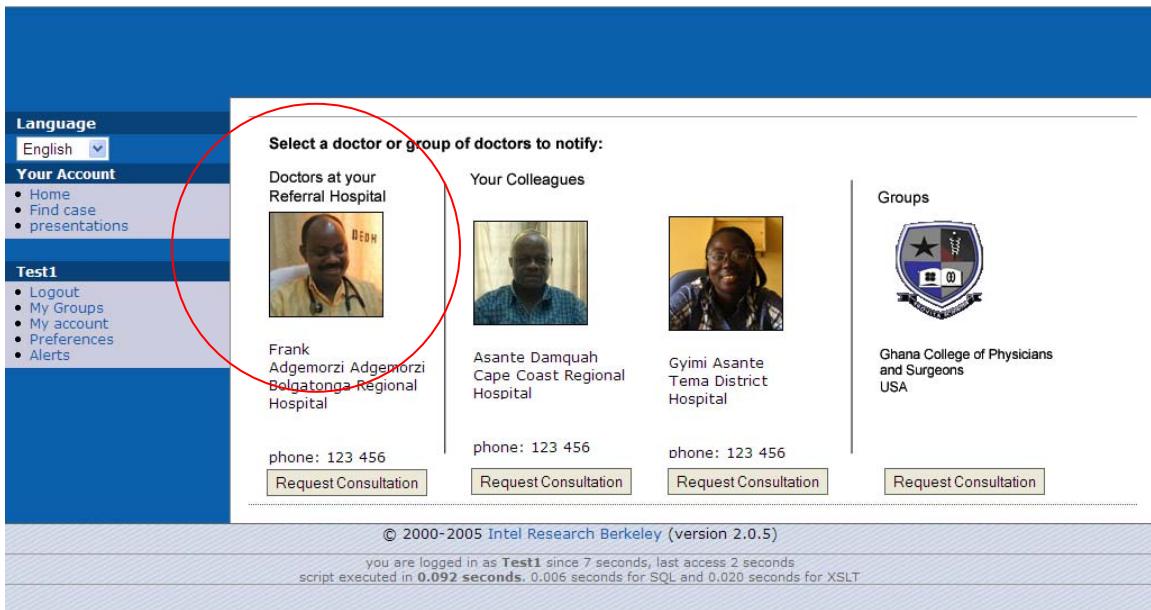


Figure 17: Notification Screen

## APPENDIX A: DESIGN LITERATURE

The literature on design is extensive, multidimensional, and highly disjointed, despite the fact that the applied nature of design lends itself to constant evolution and refinement in practice. We attempt here to provide a flavor of several methodologies that are available and argue that contextual design is the most appropriate for this community in this context, although we recognize the value of drawing out relevant components of other design methodologies. Note that this should not be interpreted as a comprehensive overview of all design methodologies, nor does it touch on periphery or cutting edge research in the field of design.

Standard usability engineering techniques, as exemplified in <sup>6</sup> and <sup>7</sup>, follow a sequence of needs assessment, competitive analysis, parallel or participatory design, guidelines and heuristic evaluations through an iterative design process. While the guidelines and heuristic are key parts of any good system, this methodologies is targeted towards building efficient, task-oriented interfaces that fulfill a given need in a certain context. However, they fail to provide a broad overview of the contexts and understanding of the user necessary to answer the question of whether we are asking the right questions.

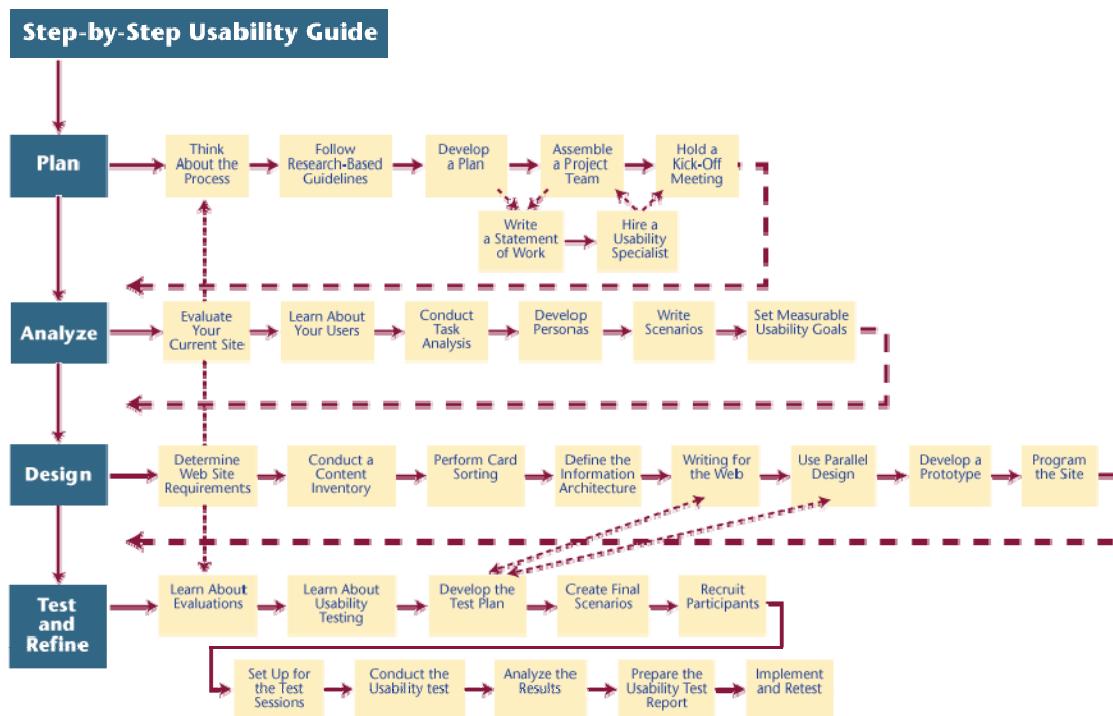


Figure A: Overview of Select Standard Usability Processes<sup>8</sup>

<sup>6</sup> Rubin, Jeffrey. *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests*. Wiley, 1994.

<sup>7</sup> Nielsen, Jakob. *Usability Engineering* (The Morgan Kaufmann Series in Interactive Technologies). Morgan Kaufman, 1994.

<sup>8</sup> <http://www.usability.gov/process.html>

A second body of literature on new product development places an emphasis not only on understanding the user in context but also on developing several phases of concept generation and selection. Here there is more of a focus on uncovering latent user needs and the development of rich personas for really targeting specific market segments. This methodology was developed largely to illicit latent needs and produce innovative designs in a user base whose physical and cultural environments may already be well defined, but does not address the context of the developing world, where the needs remain clear and universal but the constraints are quite different.



**Figure B: Brainstorming Component of New Product Development<sup>9</sup>**

Participatory design has long been vaunted and a key element in ensuring sustainable, appropriate design and ensuring that users remain invested in the process. A variety of design exercises in developing regions have taken this approach [<sup>10</sup>]. The key mandate of participatory design is high involvement of the user in the design process, at an equal footing with the designers themselves. While this methodology has a lot of promise for us, given the geographic distance of our user group and the extremely high demands on

<sup>9</sup> <http://www.ideo.com/about/methods>

<sup>10</sup> Tapan S. Parikh, Kaushik Ghosh, Apala Chavan, Puneet Syal and Sarit Arora, Design Studies for a Financial Management System for Micro-credit Groups in Rural India, ACM Conference on Universal Usability (CUU), November 10-11, 2003, Vancouver, Canada.

their time, it was unrealistic to involve them fully in the design process, although consultation was requested in variety of informal settings.

Contextual inquiry, developed by Hugh Beyer and Karen Holtzblatt incorporates a much more holistic overview of the design process, incorporating lesson from rapid ethnography and workflow analysis into an understanding the user work environment centered around a variety of work models. A key element of this is the concept of designing for the user environment, which takes into account not only the most appropriate flow for a given user task but also places an emphasis on *structure above the user interface design*. That is, there is an understanding the users can enter the system with a variety of backgrounds and goals, so an appropriate structure needs to be developed to support a variety of workflows. Assuming a single workflow is unrealistic and limiting, both for the user and the systems engineer.<sup>[11]</sup>

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<sup>11</sup> Contextual Design : A Customer-Centered Approach to Systems Designs (The Morgan Kaufmann Series in Interactive Technologies), Hugh Beyer and Karen Holtzblatt, Morgan Kaufman, 1997, ISBN: 1558604111.