Forum

A Multidisciplinary Approach to ICT Development

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Abstract

Despite large-scale investment in ICT in developing countries, information poverty has not been addressed, particularly for rural users. This article analyzes the shortcomings of current ICT design and deployment approaches and attributes the failures to both poorly designed information transfer mechanisms and single disciplinary development approaches. The article calls for adopting a multidisciplinary design approach when developing ICT interventions and proposes employing a user-centered design framework as a tool to help achieve higher user acceptance and efficient information transfer.

Introduction

After observing aggressive investment of IT companies in rural areas over the last two decades, almost all stakeholders concerned with ICT development are convinced of the positive change that communication technology can bring about (Best & Maclay, 2002; Keniston, 2002; Heeks, 2005; Toyama et al., 2005). Indeed, change is expected through offering access to relevant information services to help reduce information poverty (Prahalad, 2006; Rahim, 2008). These kinds of ICT interventions provide rural users with the knowledge to make decisions to improve their well-being, thus enhancing their economic and social development. However, if we compare the scale of ICT investment and the current impact of ICT in rural users' well-being, the results still do not make a convincing case for solving the information poverty problem (Casapulla et al., 2001; Keniston, 2002; Saith & Vijayabaskar, 2008).

Current analysis of ICT interventions deployed in rural India, which offer services such as e-governance, agriculture, education, and health care, reported low usage and low acceptance of applications by users on the following three fronts. First, the applications offered through ICT interventions were often found to be too general to be useful by rural users, and the subject information was inadequately presented (CEE, 2002; Cecchini & Raina, 2004; Chetley, 2006; Parmar et al., 2007). For example, popular ICT interventions deployed in India, such as the Gyandoot n-Logue kiosk project, have received numerous grants and awards, but the information offered through these applications was often found to be not relevant by the users (Parmar et al., 2007). Consequently, users did not see the disseminated information as providing any value to their daily lives (CEE, 2002; Jain et al., 2008). Additionally, there is no formal protocol to allow for updating and evaluating the content relevance provided through the interventions before it is presented locally. Thus, it can be said that some existing ICT interventions have poorly designed information content and weak communication strategies, and that they

lack formal mechanisms to measure changes in rural users' daily lives.

Second, ICT development for socially complex and infrastructurally weak environments, such as rural contexts, demands an understanding of several developmental issues before sustainable implementation of ICT intervention can be achieved. Solutions to these developmental issues are not often found in a single discipline. Although those with knowledge from multiple disciplines can complement one another's efforts by contributing their respective expertise to address various aspects of ICT development for rural contexts, there is no formal platform or framework with which to amalgamate the knowledge from these disciplines into the ICT development cycle. As a consequence, current ICT development has mainly followed a fragmented approach, where cross-disciplinary knowledge has not been efficiently leveraged in the development cycle (Peizer, 2003; Pentland & Barahona, 2003; Raiti, 2006). For example, technology developers are often unaware of how technology will be adapted to the local field-specific requirements and applications. Due to this lack of local contextual knowledge, issues such as availability of technological infrastructure and local maintenance of hardware and software receive less attention from technology developers. Instead, the burden of maintenance falls on the local operators or NGOs. Here, the discipline of industrial design can contribute to both understanding the local context and gathering user requirements to guide the technological development.

Lack of mutli-disciplinarity also affects content developers in that they may not be knowledgeable about the social environment and information needs of the rural users. Furthermore, issues such as how the content will be developed, maintained, and accessed by rural users locally have received scant attention (Heeks, 2002). However, there exists a wealth of knowledge related to rural social environment in the field of social sciences, but there is little evidence that demonstrates its application in designing ICT interventions (Peizer, 2003; Hafkin, 2008).

Third, considering the current ICT deployment approaches, it seems that only a few ICT deployment agencies believe in evaluating the aftermath of the project or in conducting user adoption studies. Important issues are rarely investigated, such as how ICT intervention changed users' lives, how the users benefited, or the extent to which new information addressed the current information poverty problem of rural users. The current deployment approach is further reflected in the ICT literature, where only a smattering of evaluation reports of existing and ongoing ICT deployment are showcased (Heeks, 2002; Keniston, 2002).

Reflecting on these issues, it is my opinion that the following two challenges need to be addressed when developing ICT interventions for rural contexts to disseminate information and provide services in areas such as health care, agriculture, and education:

1. How can we design and develop ICT interventions for socially complex environments, maximize information dissemination and thereby increase user adoption?
2. How can knowledge from multiple disciplines, such as social sciences, computer science, industrial design, and marketing research, be incorporated into an ICT development cycle?

Call for User-Centered Development

Based on the retrospective analysis of the ICT interventions deployed in India and on my personal experience of developing ICT interventions for education (Joshi et al., 2004) and health care (Parmar et al., 2009), it is my view that user-centered design can play a critical role here by providing a platform to address these challenges in an integrated manner to improve information dissemination via ICT interventions and thereby increase user adoption. User-centered design tries to optimize the user development around how users can, want, or need to work, rather than forcing the users to change how they work to accommodate the system or function (Norman, 1998; Preece et al., 2002; Benyon et al., 2005).

A user-centered design approach is the framework in which knowledge from scientific disciplines can converge and simultaneously address the needs of the stakeholders. The disciplines of computer science, social science, industrial design, and marketing were selected because literature reviews have consistently highlighted their relevance: social science for understanding societal issues at community and individual levels in rural areas, computer science

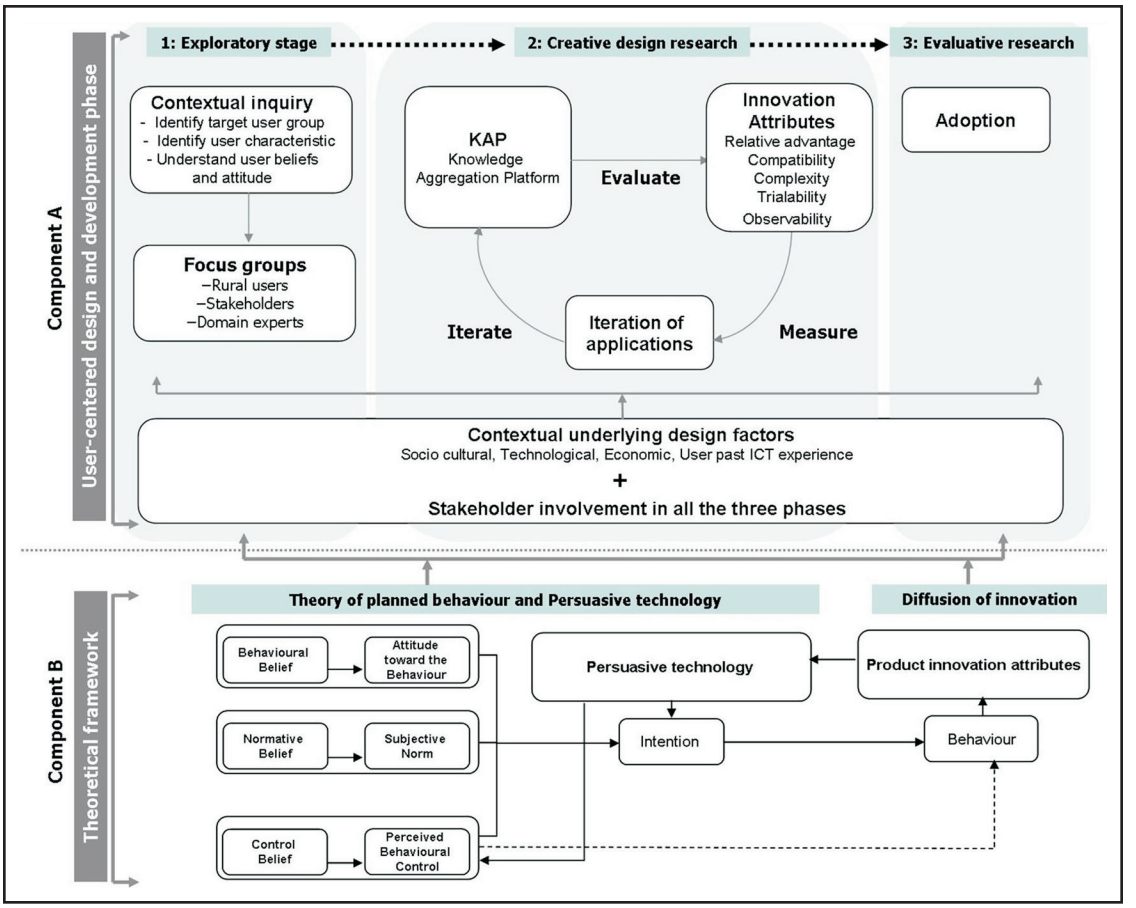

Figure 1. Proposed User-centered Design Framework.

for development of interactive device software and hardware, industrial design for designing user-interface and usability testing, and marketing for addressing issues of economic sustainability and technology adoption. Furthermore, industrial design can provide context-specific solutions to address sociocultural issues.

To address the above challenges, this paper calls for a multidisciplinary design approach for developing ICT interventions and proposes a user-centered design framework as a tool toward achieving higher user acceptance and efficient information transfer.

Proposed User-Centered Design Framework for ICT Development

The proposed ICT development framework adapts to an ISO standard user-centered design cycle (UPA, 2009) and integrates methods and theories from relevant scientific disciplines to support the main stages of the development process (see Figure 1). The following section describes this framework's two components and their application in the development of ICT intervention.

Component A: User-centered phase of the design and development cycle. This phase includes three stages: exploratory research, creative design research, and evaluative research. Together, these stages allow for empirical validation of the design and development approach.

Component B: Theoretical framework. This component explains the selection criteria and the application of the theories that have been adapted to guide the design and development cycle followed in component A. Both these components are interlinked, with component B providing the theoretical foundation to the various stages in the user-centered cycle, as defined in component A. Component B is dynamic in nature; it gives the user

both the freedom to incorporate theory appropriate to the development case and a platform to aggregate knowledge from different disciplines.

The advantage of this multidisciplinary theoretical development is that it can be used as a source of principles for guiding design innovation to address complex development issues. The theoretical understanding from component B provides guidance to apply user-centered processes to achieve focused results. For example, social science theories can provide important guidelines for investigating the user and user behavior in rural contexts. The modularity of both components is necessary to provide proper emphasis to theoretical underpinning at each stage of the development. This linking allows for generating the scientific knowledge required to give direction to future ICT development, which is often overlooked in the existing ICT development due to lack of theoretical-driven approaches. The details of both components and how they can be applied in ICT development are described next.

Component A: User-Centered Design Phases

(a) Exploratory research. Exploratory research involves the following investigations:

- Identifying the target user group, user needs, user characteristics, and social norms. It also includes accessing the knowledge level of users (baseline survey) related to the development case.
- Formulating the design brief for the ICT intervention, specifically the information content, form, and requirements for user interaction.
- Obtaining data on four contextual design factors: Socio-cultural, technological, economic and user past ICT experiences. These factors will guide the design and development process in phases (b) and (c).
- Identifying and outlining the responsibility of involved stakeholders in the design and development of the ICT intervention.

To collect user data, this phase involves user observation and user participation methods, such as contextual inquiry, focus groups, and structured interviews. The contextual inquiry method (Beyer & Holtzblatt, 1998) has been selected because it makes data gathering from users the base criterion for deciding what the system should do and how it should be structured. It allows the designer to understand context and translate contextual factors into the design of products that meet users' needs. This method has also been found effective in designing ICT-based products for developing countries (Angeli et al., 2003). These observation studies are mainly conducted in the field, along with rural users, stakeholders, local non-government organizations, and village political units. Questionnaires are based on the three factors of the theory of planned behavior that affects the human action (Fishbein & Ajzen, 1975; Ajzen, 1991). Further details on this theory are explained in section (a) of component B. A focus group method was selected as it allows the opportunity for sharing and comparing knowledge on a focused topic among participants (Stewart & Shamdasani, 1990). A focus group with stakeholders is expected to offer insight into the rural community as a whole. Furthermore, it will also validate the contextual inquiry data.

(b) Creative design action: This phase involves design, development, and iteration of the ICT intervention prototype termed the Knowledge Aggregation Platform (KAP). The KAP enables the development team to gain hands-on user experience and understand issues related to information dissemination. Additionally, it offers an opportunity to evaluate design strategies with the users from the initial design phase. Social cues from persuasive technology have been used to design information communication strategies, physical environment, and physical design of the KAP. Further details on this theory are explained in section (a) of component B. The KAP design is based on the findings from the exploratory research phase and is iterated constantly through user feedback. This iteration should improve information transfer and hence increase technology adoption. This results in the development of a dynamic evaluating mechanism that can collect user feedback in a short design cycle, thus providing an opportunity for developers to iterate ICT intervention design as per user needs. To increase the rate of adoption, the user feedback is collected on the basis of five product innovation attributes—relative advantage, compatibility, complexity, trialability, and observability—from the theory of diffusion (Rogers, 1995).

(c) Evaluative research: This phase involves evaluation of ICT intervention at two levels: The first is measuring user adoption of an ICT intervention by

conducting a longitudinal study with the users of KAP. In this phase, the results from the baseline survey (data gathered from the baseline group) collected in the exploratory research phase are compared to intervention data (from the intervention group). The findings from this phase can be documented as a basis for introducing new ICT intervention in rural areas. Longitudinal study is a type of observational study that involves repeated observations of the same items over a long period (Nachmias & Nachmias, 1996; Babbie, 2004). Longitudinal studies include cohort analysis, with a *cohort* defined as a group of people who share a common characteristic or experience within a defined period (e.g., have received intervention). Findings from this level lead to guidelines for future development of ICT design. The second phase is evaluating the user adoption on the basis of the previously noted five product innovation attributes from the theory of diffusion (Rogers, 1995). Findings regarding these product innovation attributes highlight the critical factors that contributed to high or low user adoption of an ICT intervention.

Component B: Theoretical Framework

The advantage of theoretical-based development is that it offers a scientific platform for aggregating knowledge and allows empirical validation of the design and development approach. Component B provides the theoretical foundation to the various stages of the user-centered process as defined in component A. Three stages of the user-centered design framework have been supported by the theories of planned behavior, persuasive technology, and diffusion. In the proposed framework, these theories complement one another in the understanding of user behavior and information requirements, and they are expected to contribute to successful adoption of an ICT intervention. It is interesting to note that these theories have, so far, been applied to developing ICT interventions in the Western world. However, there is a rare evidence of these theories being applied in rural contexts, which could yield new perspectives (Raiti, 2006; Parmar et al., 2008). The following describes the theories and their role in the three phases of the design framework:

(a) Exploratory stage: In the exploratory stage, the theory of planned behavior has been adopted to identify the social norms and user needs for developing ICT intervention. This knowledge will contribute to developing information content of the ICT intervention. The questionnaire is based on the three factors of the theory of planned behavior (TPB) that affect human actions (Fishbein & Ajzen, 1975; Ajzen 1991). Current literature on understanding social norms points to the TPB as a widely applied conceptual framework to understand diverse health-related behaviors, such as maintaining physical fitness, adhering to low-fat diets, using condoms for AIDS prevention, and wearing a safety helmet (Ajzen & Manstead, 2007). The theory suggests that the combination of three variables—attitude toward the behavior, subjective norm, and perceived behavior control—leads to the formation of a behavioral intention (see Figure 1). These three variables can be further understood as follows: Attitude toward the behavior results in a favorable or unfavorable evaluation of the behavior. This evaluation will provide deeper understanding about the rural users' attitude toward ICT intervention, about their feelings toward sharing information related to health, agriculture, and education, and about their perceptions of the new ICT intervention. Subjective norm considers the perceived social pressure to perform the behavior. This factor will investigate the social norms that influence rural user decision-making at the family and the community level to access information from ICT intervention. Perceived behavior control deals with the perceived capability to perform the behavior. This factor will offer insights about the user's capacity to question existing subjective norms and their abilities to change existing attitudes toward ICT intervention.

(b) Creative design research: In this phase, the social cues from persuasive technology (Fogg, 2003) have been adopted. These cues assist in designing information communication strategies to shape the existing social beliefs and practices of the rural users. Persuasive technology can be understood as any interactive computing system designed to change people's attitudes or behavior. Persuasive technology has emerged as a viable strategy for changing people's social and health-related attitudes in the West. Applications of persuasive technology range from convincing users to reduce energy consumption (Bang et al., 2006) to helping patients remember to take medication (Sterns & Mayhorn, 2006) to persuading young females to avoid early pregnancy (Fogg, 2003). Currently, use of persuasive technology has been largely limited to development of in-

formation systems in Western countries and to urban users. There is no evidence on how persuasive technology could be used in rural areas of developing countries to address sociocultural issues related to new ICT development.

In the creative design research, the design and development process of the ICT intervention employs persuasive strategies in designing information communication strategies, physical environment, and physical system design. The role of persuasive technology is to shape existing social norms via an interactive system to motivate rural users to have high behavior intention and thereby increase their perceived behavior control. As depicted in Figure 1, persuasive technology is projected as a means to persuade rural users to have high perceived behavioral control, thus high behavior intention.

(c) Evaluative research: In this phase, innovation attributes from the diffusion theory aid in evaluating the ICT intervention in the longitudinal study. To measure the impact of ICT intervention, results of the longitudinal study should be compared to baseline data obtained in the exploratory phase. The findings from this phase should measure the improvement in information dissemination offered via ICT intervention and act as an indicator for measuring user adoption. The results from this phase will offer insights about the role ICT intervention played toward improving users' well-being. These learnings would provide guidelines for future ICT development.

Conclusion and Future Work

Information poverty cannot be addressed by just giving away computers and installing Internet connections in rural areas. What is really needed is to offer rural users relevant, personalized information that enables them to make positive changes in their daily lives, rather than give them the type of information that is typically enforced. We should view ICT as a tool, and not as the solution, toward building knowledge-based societies. With the proposed framework, stakeholders involved in the development of ICT interventions can leverage knowledge from multiple disciplines to develop sustainable projects. This knowledge, applied in the three phases of the user-centered framework, will provide understanding into user requirements and into developing customized content through involvement of rural users in the early stages of the development cycle. It will finally offer an opportunity to evaluate and monitor the impact of ICT intervention in achieving positive social and economic change. To validate the user-centered design framework, a practical project that focuses on disseminating personal health information to rural women has been identified. The design of the deployed prototype has been based on the proposed framework. Preliminary results of field evaluation have indicated positive changes in shaping social beliefs of the rural women, thereby improving health information dissemination (Parmar et al., 2008; Parmar et al., 2009). ■

References

Ajzen, I. (1991). "The theory of planned behavior." *Organisational Behavior and human decision processes 50* (2), 179–211.

Ajzen, I., & Manstead, A. S. R. (2007). Changing health-related behaviors: An approach based on the Theory of Planned Behavior. In K. van den Bos, M. Hewstone, J. D. Wit, H. Schut, and M. Stroebe (Eds.). *The scope of social psychology: Theory and applications* (pp. 43–63). New York: Psychology Press.

Angeli, A. D., Athavankar, U., Joshi, A., Coventry, L., & Johnson, G. I. (2003). Introducing ATMs in India: A contextual inquiry. *Interacting with Computers* 16 (244), 29–44.

Babbie, E. (2004). *The practice of social research.* Belmont, CA: Thomson Learning.

Bang, M., Torstensson, C., & Katzeff, C. (2006). The PowerHouse: A persuasive computer game designed to raise awareness of domestic energy consumption. In W. Ijsselsteijn, Y. D. Kort, C. J. H. Midden, B. Eggen, & E. van den Hoven (Eds.). *Persuasive 2006* (pp. 123–132). Springer-Verlag Heidelberg.

Benyon, D., Turner, P, & Turner, S. (2005). *Designing interactive systems: People, activities, context, technologies.* Addison Wesley/ Pearson Education.

Best, M. L., & Maclay, C. M. (2002). Community Internet access in rural areas: Solving the economic sustainability puzzle. In G. Kirkman,

J. Sachs, K. Schwab & P. Cornellius (Eds.). *The Global Information Technology Report 2001–2002: Readiness for the Networked World* (pp. 76–88). Cambridge, MA: Oxford University Press.

Beyer, H., & Holtzblatt, K. (1998). *Contextual design: Defining customer-centered systems.* San Francisco: Morgan Kaufmann Publishers.

Casapulla, G., Cindio, F. D., & Ripamonti, L. (2001). Community networks and access for all in the era of the free Internet: Discovering the treasure of community. In L. Keeble and B. D. Loader (Eds.). *Community informatics: Shaping computer-mediated social relations.* New York and London: Routledge.

Cecchini, S., & Raina, M. (2004). Electronic government and the rural poor: The case of Gyandoot. *Information Technologies and International Development 2*(2), 65–75.

Centre for Electronic Governance (CEE). (2002). *Rural cyber cafes on Intranet: A cost evaluation study of project Gyandoot, Dhar, Madhya Pradesh, India.* Ahmedabad, Gujarat, India: Indian Institute of Management.

Chetley, A. (2006). *Improving health, connecting people: The role of ICTs in the health sector of developing countries.* (A framework paper). Infodev, World Bank. Washington, DC.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research.* Reading, MA: Addison-Wesley Publications.

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do.* San Francisco: Morgan Kaufmann Publishers.

Hafkin, N. (2008). Enabled women in knowledge societies. *Information for Development. 6,* 6–8.

Heeks, R. (2002). Information systems and developing countries: Failure, success, and local improvisation. *The Information Society 18,* 101–112.

Heeks, R. (2005). ICTs and the MDGs: On the wrong track? i4D. February, 9–12.

Jain, R., Dey, A., Abraham, R., & Padmanabhan, V. (2008). Two mutually reinforcing applications of ICT for socio-economic development of India. In A. Saith, M. Vijayabaskar, and V. Gayathri (Eds.). *ICTs and Indian social change: Diffusion, poverty, governance* (pp. 93–112). New Delhi: SAGE.

Joshi, A., Parmar, V., Ganu, A., Mathur, G., & Chand, A. (2004). Keylekh: A keyboard for text entry in Indic scripts (928–942). CHI 2004. Vienna: ACM digital library.

Keniston, K. (2002). IT for the masses: Hope or hype? Accessed in May 2003 from: http://web.mit.edu/?kken/Public/PDF/ASCI Journal Intro ASCI version.pdf

Nachmias, C. F., & Nachmias, D. (1996). *Research methods in the social sciences,* London: Arnold.

Norman, D. (1998). *The design of everyday things.* Cambridge, MA: MIT Press.

Parmar, V., Groeneveld, G., Jalote-Parmar, A., & Keyson, D. (2009). *Tangible user interface for increasing social interaction among rural women.* Tangible and embedded interaction (TEI'09). Cambridge, United Kingdom, ACM, New York. 139–145.

Parmar, V., Keyson, D., & de Bont, C. (2007). IFIP International Federation for Information Processing, Shaping social beliefs: A community sensitive health information system for rural India. In A. Venkatesh, T. Gonzalves, A. Monk & K. Buckner (Eds.). *Home informatics and telematics: ICT for the next billion* (133–143). Boston: Springer.

———. (2008). Persuasive technology for shaping social beliefs of rural women in India: An approach based on the theory of planned behavior. In H. Oinas-Kukkonen, P. Hasle, M. Harjumaa, K. Segerstahl & P. Ohrstrom (Eds.). *PERSUASIVE 2008* (104–115). Oulu, Finland: Springer.

———. (2009). Persuasive technology to shape social beliefs: A case of persuasive health information systems for rural women in India. *Communications of the Association for Information Systems 24:* 427–454.

Peizer, J. (2003). Cross-sector information and communications technology funding for development: What works, what does not, and why.

Information Technologies and International Development 1(2), 81–88.

Pentland, A., & Barahona, J. C. (2003). Marketplace of ideas. *ICT4D Conference,* Kuala Lampur.

Prahalad, C. K. (2006). The innovation sandbox. *Strategy Business, October,* 44.

Preece, J., Rogers, Y., & Sharp, H. (2002). *Interaction design: Beyond human-computer interaction.* New York: John Wiley & Sons.

Rahim, R. A. (2008). Creating a world of equal opportunities. *Information for Development 6,* 11–14.

Raiti, G. C. (2006). The Lost Sheep of ICT4D Research. *Information Technologies and International Development 3*(4), 1–5.

Rogers, E. M. (1995). *Diffusion of innovations.* New York: The Free Press.

Saith, A., & Vijayabaskar, M. (2008). ICTs and Indian social change: An agenda of concerns. In A. Saith, M. Vijayabaskar, and V. Gayathri (Eds.). *ICTs and Indian Social Change: Diffusion, Poverty, Governance* (pp. 13–17). New Delhi, SAGE Publications.

Sterns, A. A., & Mayhorn, C. B. (2006). Persuasive pillboxes: Improving medication adherence with personal digital assistants. In W. IJsselsteijn, Y. D. Kort, C. J. H. Midden, B. Eggen, & E. van den Hoven (Eds.). *PERSUASIVE 2006* (195–198). Springer-Verlag Heidelberg.

Stewart, D. W., & Shamdasani, P. N. (1990). *Focus groups: Theory and practice.* London: SAGE Publications.

Toyama, K., Kiri, K., Menon, D., Pal, J., Sethi, S., & Srinivasan, J. (2005). PC kiosk trends in rural India. *Seminar on Policy Option and Models for Bridging Digital Divides.* Tampere, Finland.

UPA. (2009, June 21). What is User-centered Design? Retrieved from http://www.upassoc.org/usability_resources/about_usability/what_is_ucd.html