New Product Development Processes for ICT-for-Development Projects

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Abstract--**The potential applicability of established new product development processes to information and communications technology (ICT)-for-development projects is investigated. The demand for ICT solutions to serve numerous societal information needs in developing regions of the world is increasing rapidly. A number of methods and practices have been used by organizations to develop and deliver such ICT solutions, but a need exists to formalize product development processes for use in the ICT-for-development context. Existing literature on product development in the ICT-for-development context is explored to derive a theoretical model that may be suitable for addressing product development process problems encountered in such projects. An ICT-for-development project to disseminate government information to rural communities with limited literacy is evaluated against the derived theoretical model in a case study. The project was carried out by the CSIR (Council for Scientific and Industrial Research), a government agency in South Africa. The presence and positive effect of certain established product development practices is identified, while the absence or unsatisfactory execution of other established practices are assessed for their contribution to decreased levels of product success.**

I. INTRODUCTION

An opportunity exists worldwide to prioritize the development of ICT applications for the world's poor in developing countries, with nearly half the global population living on less than US$2 per day. A key question is how the Internet should be delivered to the five billion people in the world who currently do not have any access. A number of solutions are proposed, including a shift of focus to delivering information via mobile phones, with more than half the world's population (including the poor) being mobile phone users. In addition, an active innovation perspective proposes that the private market will not deliver anything of real value soon enough to the poor, requiring an intervention to drive new types of innovation, for example, participative user-engaged design processes, or enabling the poor to become innovators themselves. [15]

A. Human Language Technology development in South Africa

Equitable access to information is highlighted as one of the major challenges in South Africa [9]. Similar considerations are prevalent in other developing countries [36]. The South African government is faced with the challenge of delivering services at a suitable level of quality and efficiency. Government policy has been created to ensure that all people in South Africa are provided with equal access to information, regardless of their economic status, cultural background or language that they use to communicate. E-Government in particular makes use of ICT in order to facilitate government service delivery in most developed countries, and is on the rise in developing regions of the world.

Technology enabled services however tend to be out of reach for those who are illiterate and poor. Automated telephone-based services are viewed as a viable method for reaching out to those who are faced with information access barriers such as infrastructure, language and literacy [1].

The background to this research was provided by a number of projects that have been conducted at the CSIR (Council for Scientific and Industrial Research: South African government agency for scientific and industrial research). The work has been done by the CSIR's Meraka Institute and has been aimed specifically at providing ICT based services, including health-care and government based information services to developing sectors in and around South Africa [24, 30]. The abovementioned systems employ a number of ICT technologies, including well established interactive voice response telephony systems, text messaging, as well as technologies totally new in South Africa's multilingual environment, specifically, native language speech-based-technologies like text-to-speech (TTS), and automatic speech recognition (ASR) systems.

One of the more recent projects undertaken was the Lwazi project, commissioned by the South African department of Arts and Culture (DAC) in 2006. The aim of the project was to enable the development of a multilingual telephone based information service in the nation's eleven official languages to assist government in service delivery and to overcome both language and literacy barriers [21]. The project culminated in the development of a service aimed at a government based community development worker initiative. The government initiative established community service centers across the country, with the objective of providing integrated services and information from government to communities, and with the primary goal of improving access to government services across the country, especially in marginalized communities.

The service developed during the Lwazi project was aimed at alleviating a key challenge facing community service centers and their respective community workers, namely the objective to ensure that up to date government based information was made available to them, and that this information could be disseminated effectively via community workers to their surrounding communities. The developed service provides a web site that enables community service centre managers to upload new announcements for community workers and/or community members, and to listen to voice messages left by community workers. Two automated telephone services are also provided, one aimed at

community workers and the second at community members. Both phone services provide access to announcements uploaded by community service centre managers, and allow voice messages to be left for community service centre managers. Speech based technology is incorporated into the phone based services, enabling text based messages left by community centre managers on the web site to be rendered into audio using a text-to-speech engine, which can then be accessed via a phone. A unique aspect of the service is the provision of a text-to-speech capability in all of South Africa's eleven official languages, which had never before been achieved. A particular challenge is the complex variety of sounds, including tongue-clicking, that has to be designed for.

The overall levels of end-user uptake for the resulting Lwazi services has however to date been questionable. The total level of usage during service pilot trial as well as extended testing was less than one unique unit of usage per day over a period of more than a year. As detailed in [30], the low uptake of the service can be attributed to number of factors, as shown in Table 1.

TABLE 1. LWAZI PROJECT LOW END-USER UPTAKE FACTORS [30]

Limited availability of information sources to provide relevant and timely content for the service. This is a critical element required to drive overall usage, but is a general challenge for speech based applications for the developing world.
Technology readiness of system components impacting overall usability and service acceptance, in contrast to using established technology.
Targeting users with varying degrees of communication barriers (low to high), instead of focusing on users with high barriers to communication.
Limited user buy-in and uptake attributed to users being given a limited perception of overall sustainability due to a short term pilot approach, versus a more permanent solution.

B. Research problem statement and objectives

A need exists to formalize product development practices in the context of ICT-for-development projects. The current lack of product development practices in the context of ICT-for-development projects potentially contributes to the low success rates of ICT solutions in the developing world context in terms of serving actual needs of end-users. The following research questions were derived from the introduction to problem above:

- What product development process stages, activities and decision criteria are applicable for ICT-for-development projects?
- How should end-users be involved in the product development process for ICT-for-development projects?
- What level of product development process adaptability (e.g. spiral process practices) is applicable for ICT-for-development projects?

The longer term goal of this research is to establish new product development practices suitable for use in ICT-for-development projects, in order to improve the success of serving actual end-user needs. The objective of this study was to take initial steps in this direction by (a) testing traditional new product development practices in the ICT-for-development context, and (b) identifying aspects unique or accentuated by the ICT-for-development context. The study focuses on the applicability of established practices from existing models.

II. CONCEPTUAL METHOD AND THEORETICAL FRAMEWORK

A. ICT-for-development product development challenges

It is widely accepted that the delivery of ICT based products and services in developing world contexts presents quite a formidable challenge. Failures occur due to factors such as inferior initial conditions, less developed infrastructure and complementary structures and lower stakeholder familiarity with intended solutions. ICT may not just provide an incremental improvement in efficiency, but can represent or catalyze enormous social shifts [14].

Tongia and Subrahmanian [31] frame ICT-for-development as a design problem, using several cases to analyze failures and successes. The nature of ICT-for-development is said to be ill-defined, with much of the literature being ad-hoc or anecdotal, which complicates the decision on an appropriate process to adopt. A number of product development challenges for the ICT-for-development context are raised. *Stakeholder inclusion* is emphasized, highlighting the need to address information asymmetries that exist between stakeholders, and giving specific attention to involving end-users in the decision making process. The need for general methods for *user-participation* in product design and development indicates a gap that could be addressed by applying existing product development practices here. Problem wickedness ([25] in [4]) is also raised as a specific issue, which seems to manifest primarily in the form of *scoping risk*, where it is difficult to pin down what the problem domain is, and what potential solutions exist.

Software projects are argued by DeGrace and Stahl [8 in 17] to share the characteristics of wicked type problems put forward by Rittel [26 in 17]. New product development and design problems are suggested by Hey [17] to represent wicked problems, where problem setting is the key. The design community has focused on the 'reflective conversation' metaphor for design [28 in 17], which proposes a model of design based on the study of practitioners and a framework through which to analyze design activity.

Gumienny [12] emphasizes that the ambiguous quality of wicked design problems cannot be addressed by the scientific methodology, but rather with an explorative and subject driven approach, also linking here to Schön's "reflective conversation with the situation" [28 in 12]. This paradigm is divided into two different ones as follows. The first relates to the current popular human-centred design paradigm where the situation of a design problem is mainly constituted by stakeholder (i.e. user) perspectives. Here the tacit human-centred information acts as a key component of design

processes [18]. The second relates to the author-design paradigm, where the subjective experience of the designer constitutes the perception of the situation. Here professional expertise and self-confidence are important prerequisites, bringing author-design into a line with artistic activity.

Lanzara [19] emphasizes the view of design as problem setting, arguing this as a much more significant challenge than problem solving itself. Furthermore, this challenge consists mostly out of framing of the situation by designers, where framing is defined as identifying a desired goal, highlighting some aspects and hiding others, and selecting boundaries for the situation and criteria for evaluation. The ultimate goal is to frame a problem in a way that leads to a product users want, requiring a frame based on core customer needs

B. General practices for product success

Product development processes have been described as the sequence of steps or activities which an organization uses to conceive, design and commercialize a product [32]. Established sources exist that describe the typical phases and activities involved in successful product development [7, 32].

A generic product development process is proposed by Ulrich and Eppinger [32], which embodies a key management objective of multidisciplinary integration of various business functions (e.g. management, engineering, and marketing). The generic product development process is described as an information processing system, beginning with inputs such as corporate objectives and technology availability and capabilities, product platforms and production systems. Various activities process the development information, formulating specifications, concepts and design details. The process concludes when all information for supporting the product deployment has been created and communicated.

The importance of listening and responding systematically to the voice of the customer is stressed in [6]. This aspect is listed as one of the critical success factors leading to overall product success. It is explained that the voice of the customer should be an integral part of the new product process from the start with idea generation (e.g. customer focus groups). Market research and customer inputs should be used as inputs into the product's design, and not a simple confirmation thereof. In addition, the customer can be made a part of the development process via constant rapid-prototype-and-test iterations.

As discussed in [7], the Stage-Gate® process has become a popular system for driving new products to market. The concept of Stage-Gate is briefly outlined, with specific notes on how the system should work, including the structure of both stages and gates. A Stage-Gate process is described as a conceptual and operational map for moving new products from idea to launch and beyond. The Stage-Gate process draws best-practices from successful projects and project teams, and puts mechanisms in place for projects in general to improve their performance. Each stage is composed of a set of required or recommended best-practice activities needed to progress the project to the next gate or decision point. Gates serve as quality–control checkpoints, "go/kill" and prioritization decisions points, and points where the path forward for the next part or stage of the project is agreed to [7].

Proposition 1*: Established product development phases and activities will increase the likelihood of success for developing incremental products in the ICT-for-development context.*

C. User participation within the product development process

Established product development practices contain a number of customer involvement techniques, including (a) initial user needs, values and benefits assessments, (b) initial concept creation, (c) concept testing using initial mock-ups or prototypes, (d) user feedback from more complete product prototypes during development, (e) user field trials during testing and validation, and lastly (f) post launch monitoring and evaluation.

According to [27], design ethnography provides a way of understanding the particulars of daily life, such as to increase the success probability of a new product or service, mitigating prevalent risks of failure relating to a lack of understanding of basic consumer behaviours. The challenge is to find ways of presenting data to product development teams in a way that conveys the richness and texture of day-to-day interaction and culture. Furthermore, design ethnography acknowledges human desire for new products and services, and provides a language and set of practices for talking about ongoing invention of products and cultures. The role of the design ethnographer is to express the relevant context of one culture to another, without necessarily conforming to strict scientific notions of data to achieve this. Social intimacy is one of the core aspects of any fieldwork project, requiring anthropologists to spend lengthy periods (months/years) in the field in order to establish trust. This can also be aided by employing translators/consultants with strong connections to the local community.

Traditional market research methods do well at quantifying customers' preferences regarding existing solutions, but fail to identify needs people can't readily articulate [23]. Research methods from sociology and anthropology are being employed to obtain more qualitative information on customers, resulting in a rich description of consumers' behaviour and context. These tend not to be prescriptive, rarely focusing on needs and actual business opportunities.

Need finding proposes that these qualitative methods must be better integrated into the process of design and development. Furthermore, Need finding is described as a qualitative approach to study people and identify their unmet needs [23]. It is acknowledged that even the most detailed description of consumers' behaviour won't help product developers if it doesn't expose opportunities for action. In addition, solely relying on detailed descriptions may never

uncover a need. Many needs are apparent only after they have been solved (wicked principle).

Central principles of Need finding are introduced, including (i) a focus on searching for needs, not solutions, keeping all possible solutions open for consideration; (ii) making research and design seamless by using individuals trained in studying people and design conceptualisation, greatly reducing time to translate between the research and design stages of a product; (iii) going into the customers environment to obtain the richest information on people's needs by first hand observation of user activities, and not relying on consumer memory or descriptive ability, or need awareness; (iv) looking beyond the immediately solvable problem by recording and analyzing issues that may seem beyond the scope of the immediate project; (v) letting the customer control proceedings and guide activities and discussions – at least to the extent that these relate to the research topic, effectively limiting designer bias due to prompting users; (vi) Recording all forms of data (e.g. body language); (vii) making findings tangible and prescriptive, presenting findings in a vivid and actionable form, allowing a smoother transition between studying people's needs and creating new ways to meet them; (viii) iterating to refine findings, allowing design work to proceed in parallel with the research.

Veryzer [35] proposes that a user oriented design emphasis can contribute to the new product development effort and serve as a focal driver of that effort, ensuring that both the realities of the application (user needs) and the realities of the market are addressed. Furthermore, it is suggested that user oriented design as a focal driver can produce a more comprehensive approach toward new product development, keeping a project on track and producing a grounded product that provides maximal utility to the user. It can also potentially result in cost savings due to reductions in redesign and shortened development durations.

Information integration is said to be the essential element for dealing with the external and internal integrity of a product, where internal integrity is referred to as consistency among a products functions and structures and its development, and external integrity is referred to as the match between the product and the intended user. User oriented design is said to promote information integrity by providing a crucial fixed point toward which the efforts of each of the contributing professions can focus, integrating multiple disciplines (human sciences like sociology or anthropology, industrial design, and marketing), and resulting in a designed user experience that innovates.

Current techniques in the field of anthropology are also acknowledged, in particular work by Cagan and Vogel [3 in 35]. Specifically, ethnographic methods have been employed during the preliminary stages of new product development using fieldwork to observe the end-user group and to derive patterns of behaviour, belief and activity. The data collected using these techniques are shared among innovation team members to provide a better sense of end user intent.

Mock-ups and prototypes at different points of the development process are also acknowledged to be an important for design and user oriented design in general. Furthermore, user oriented design employs physical representation as a communication tool to create a common context, potentially spanning language boundaries between disciplines. Also, concept testing is made problematic due to uncertainty as to the fit between a proposed concept and actual user needs [22]. Both prototyping and qualitative marketing research techniques are suggested to be more necessary today than in the past.

Guerzoni [11] defines user sophistication as the degree of consumer need awareness. This awareness is positively correlated with the consumer's ability to communicate their needs to firms. Furthermore, only consumers who are well aware of their needs can provide feedback with adequate accuracy. This is said to be especially true for radical product improvements. ICT-for-development stakeholders are expected to have a low familiarity with solutions, with users being a major stakeholder grouping ([10] in [31]). Users within the ICT-for-development context per definition exhibit a low level of sophistication (low technical and needs awareness). It is expected that the level of user involvement will be limited to gathering and evaluation of needs based information only, and that these users will not be involved in solution creation, design or development activities, as would be the case for user-innovators who have higher technical capabilities and need awareness [16, 37].

Proposition 2*: Established product development practices will be used for involving unsophisticated users in the development of incremental products*

D. Scoping risk management

The product development process has been described as a risk management system, where risks are reduced according to the progression of the process [20, 32]. Product development risk is mentioned in [33] to lead to several forms of development failure, including slow or late products missing a market opportunity, technically challenging products impossible to design, lack of expected features, or a product with misguided specifications that do not fulfill user needs.

Product development processes are discussed in [33] to address risk through development iterations, integrations and reviews, with iterations aimed at addressing market risk, and reviews addressing technical risk. Planned iterations, such as early prototypes can be used for design improvement. Based upon the abovementioned scoping risk prevalent within the ICT-for-development context, it is deemed necessary to determine the level of process adaptability required to manage this risk. In order to achieve this, it is suggested that the required level of iteration and review be measured for the ICT-for-development context.

Proposition 3*: Scoping risk can be mitigated by using planned iterations and design reviews in the ICT-for-development context*

III. RESEARCH METHODOLOGY

This research takes the form of a descriptive case study. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used [2]. The goal of case studies is to expand and generalize theories, described as analytic generalization, and not to generalize to populations typical of statistical generalization [38]. Case studies require multiple sources of evidence, allowing one to develop converging lines of inquiry for applying the process of triangulation [2].

As stated by Yin [38], the research questions posed by a study should cater to the unit of analysis of the case study. Furthermore, Yin [38] mentions that one can differentiate between single and multiple case studies. Single case studies are typically appropriate for investigating extreme or unique cases, and may also be driven by pragmatic reasons such as access to rare information. Multiple case studies can be more appealing since their results are viewed to be more robust, and are strengthened by the use of replication logic. The difficulty of generalizing from case studies is also considered, where the suggested remedy is that a case study should be viewed as an experiment, or a unit, where benefits can be obtained from a single case that is a critical exemplar of that theory. In addition, multiple case studies may be considered equivalent to multiple experiments, where generalization can be achieved by virtue of replication logic across cases.

Flyvbjerg [10] stresses that one can often generalize on the basis of a single case, and that the case study may be central to scientific development via generalization as a supplement, or alternative to other methods. In addition, it is stated that formal generalization is overvalued as a source of scientific development, whereas "the force of example" is underestimated. The strategic choice of cases in social sciences may add greatly to the generalizability of a case study. Lastly, it is mentioned that the absence of formal generalizability alone does not restrict the collective process of knowledge accumulation.

The unit of analysis for this case study is the product development process employed during the Lwazi project, executed by the CSIRs Meraka institute. A single case study was conducted here on the product development process that was followed during an ICT-for-development project conducted by the CSIRs Meraka institute.

It is further suggested by Yin [38] that an analysis strategy be determined before data collection commences. One strategy suggests that propositions be defined that reflect the research questions and literature review, as well as new insights. These propositions will determine the nature of the data collection plan. This approach was adopted for this study, where research questions were developed aimed at determining what product development process practices would be applicable within product development projects in the ICT-for-development context.

The overall data collection for this study was aimed at enabling the measurement of the presence and suitability of established process stages, activities, outputs and methods. Established practices provide an existing framework for defining the overall product development process stages, activities, outputs and methods. An established practice framework was drawn up based on established product development models, including the Stage-Gate model [5], and the Generic product development process [32].

Another core aim of the overall data collection was to provide an end-to-end description of the product development process employed by the organisation. Various document and archive sources were used to provide an account of the various process stages, activities, and methods employed. Participant observation was also used to confirm and enhance the description of events as they happened. An interview questionnaire was also developed based upon the above established practices framework. Semi structured interviews were conducted with key product development team members. The interview data collection was aimed at confirming the product development process description from other sources, and also to provide personal accounts from team members regarding the presence and suitability of the various product development stages, activities and methods.

IV. RESEARCH RESULTS

Data was gathered from the previously mentioned sources and analyzed in order to determine the presence and suitable execution of established product development practices. For each phase the information from the project documentation is summarized, and then compared with the data from the other sources, predominantly interview data.

A. Preliminary market investigation

Both market attractiveness and product acceptance potential were investigated by the product development team using a number of sources, including internal sources (product development team, fellow employees), external sources (e.g. non-profit organizations, government departments), and potential end-users (e.g. community workers, community members). In addition, various investigation factors were defined and used to gather general user needs and demographics at preliminary target areas, including community information needs, information sources, technology suitability (speech base application medium), user experience (literacy and technology exposure), and lastly potential for uptake. A number of investigation methods were also used to engage with users, including interviews, focus groups and community surveys (sample not representative). An eventual product target group was defined, namely community centre managers, community workers as well as the surrounding community members. Lastly, no preliminary competitive analysis was present.

The outputs of the preliminary investigation included (a) user needs and demographics at a rough or macro level, (b)

potential user benefits (e.g. the need for up to date and relevant government information and its dissemination between government, community centre managers, community workers and community members), and (c) a perceived level of user enthusiasm, as well as early concept ideas from users.

The general presence of the overall preliminary market investigation was confirmed across sources. Both market attractiveness and product acceptance were assessed. Respondents raised concerns that the market investigation was not objective or representative, or in depth enough to understand real user-needs. The overall objective of the preliminary market investigation is to conduct a quick and inexpensive assessment, relying on readily available sources [5:137]. It can however be argued that the overall aim of the preliminary investigation is not to be completely objective or in-depth at this stage, and that the outputs produced, e.g. macro user needs and demographics and must-meet criteria, are sufficient for a preliminary investigation. Market attractiveness and product acceptance assessments are thus proposed to have been executed suitably. All sources confirmed the absence of a preliminary competitive analysis.

B. Preliminary technical investigation

Rough performance objectives and preliminary technical feasibility were assessed as follows. Technical performance objectives were defined at the onset. Firstly, a need was defined for a software application development and delivery platform for automated telephone based services, as well as web based services, capable of delivering service to users at a real world scale. In addition, a need was defined to incorporate speech based technologies (e.g. TTS and ASR) in the automated telephone based services. Preliminary technical feasibility assessments were conducted with respect to key risks faced at the time. This included initial technical proof of concepts for speech technology and telephony integration, as well as automated telephone application mock-ups and service scalability tests. There was a substantial reliance on previous lessons learnt and expertise gained from previous product developments for the overall preliminary technical investigation.

The presence of the preliminary technical assessment was confirmed across sources. Rough performance objectives were determined, and preliminary technical feasibility and operational assessments were performed. No concerns were raised for the establishment of rough performance objectives or the operational analysis. A number of concerns were however raised regarding technical feasibility assessments, including a reliance on previous knowledge and experience, as well as overconfidence in certain technical capabilities at the cost of user acceptance. The evident technical feasibility assessment concerns are corroborated by the post-project issues, as summarized in Table 1, specifically with regard to how TTS system readiness impacted overall usability and acceptance of the product downstream. The overall preliminary technical investigation is thus found to be suitable, with the exception of the technical feasibility assessment.

C. Preliminary phase evaluation

The overall outputs from the preliminary investigation of the eventual selected product as well as other potential ideas at the time served as inputs for establishing product must-meet criteria using morphological analysis [24], essentially a qualitative problem structuring method. Additional classification of must-meet criteria was conducted during a collaborative workshop involving the development team and colleagues. Lastly, selection of the eventual product concept was conducted between the research group management and the development team using the defined must-meet criteria. Strategic priorities were also used to make the selection, namely, novelty, stakeholder partnerships, and potential for impact on rural individuals. The outputs of the preliminary phase evaluation included product must-meet criteria, a preliminary product concept as well as a go-ahead decision and planning for the detailed investigation.

The presence of the preliminary phase evaluation was confirmed across sources. Significant concerns were raised, stating a reduced focus on delivering superior value to end-users. The evaluation did not seem to be objective or formal, and strategic objectives pushed for technical novelty (e.g. speech technology solution versus basic text messaging) taking precedence over a clearly defined market or delivering superior benefits to end-users. The concerns are corroborated by the above unsuitable technical feasibility execution, which should typically be flagged at evaluation. Phase output evaluation as well as go/kill recommendation is thus found to have been unsuitably executed due to insufficient contingencies regarding TTS readiness and impact on user acceptance. The overall preliminary phase activity presence and suitability of execution is summarized in Table 2.

D. Detailed market investigation

Following the outcomes of the preliminary investigation and idea selection, additional site visits were conducted at community centers across the country. Information was gathered according to the investigation criteria established during the preliminary investigation. This was done in order to corroborate findings from sites already visited, as well as to gather missing information subsequent to the initial visits. The outcome confirmed user needs and demographics at a macro level and clarified findings at sites not previously visited. The same investigation methods were employed here, namely interviews, focus groups and rudimentary community and household surveys. Additional attention was also given to establish a general understanding of the existing system of use of the community centre managers, community workers and surrounding communities. A main objective of the follow-on site visits was to establish stakeholder relationships for eventual application piloting.

All the information gathered during the preliminary and detailed user needs analysis was fed into the overall product

design activity, involving rigorous collaborative multidisciplinary sessions including social scientists, application designers and engineers, speech technology engineers and the research group management. Lastly, no detailed competitive analysis was present. The outputs of the detailed market investigation included (a) macro user needs and demographics confirmed across the target group, (b) a general understanding of the existing system of use, and (c) a general product concept design based on gathered user needs.

The presence of the detailed market investigation was confirmed across sources. User needs were assessed again at this stage, and a general understanding of existing system of use was defined. There were however concerns that the needs analysis lacked an in-depth understanding of real user benefits and system of use. In addition, strategic priorities (research outputs and infrastructure) took precedence over immediate end-user needs. This is corroborated with the finding that user enthusiasm at this stage did not correlate with eventual uptake. Post project issues (Table 1) also indicate that real user benefits were not really understood, including overall low uptake due to limited information content providers (only community centre managers), and user preference based on the availability of alternate means of communication (e.g. e-mail, subsidized phones). The overall detailed market investigation is thus found to have been unsuitably executed. Lastly, all sources confirmed the absence of a detailed competitive analysis.

E. Detailed technical investigation

Detailed performance objectives and preliminary technical feasibility were assessed by product team engineers based upon a more detailed product concept definition. In contrast to the preliminary technical assessment, focus was directed to defining and assessing specific features required. This included enabling free user phone calls (call back or missed call capability), support for multilingual application content as well as TTS service infrastructure and multilingual support. The technical assessments drew from lessons learnt and outputs from previous product developments. For example, they relied upon service scalability and operational assessment data as well as speech technology telephony proof of concept integrations from prior developments. The outputs of the detailed technical investigation included (a) detailed technical product system and component concept designs (e.g. phone service call-flows, web site design), (b) detailed technical performance objectives and feasibility assessments, and (c) an overall technical platform architecture.

The presence of the detailed technical investigation was confirmed across sources. All sources confirmed detailed performance objective definition, that there was a detailed technical feasibility assessment, and that existing infrastructure and previous experiences and lessons learnt were capitalized on. Concerns were raised regarding the feasibility assessments, with TTS readiness issues being accepted due to strategic objectives, leading to eventual user acceptance issues as corroborated in the post project issue findings (Table 1). This also had a knock-on effect resulting in user needs and market inputs not being translated into a feasible product concept. Lastly, there was a perceived lack of consideration for the larger operational context (long term service scaling and operation) attributed to a narrow prototype vision. These may in turn be attributed to post project issue findings regarding limited service sustainability or user buy-in due to an overall short term pilot approach. The overall detailed technical investigation is thus found to have been executed in an unsatisfactory fashion, with the exception of the definition of detailed performance objectives, for which no concerns were raised.

F. Concept testing and design iteration

No concept testing or design iteration with users was present during the detailed investigation. There was instead a reliance on previous lessons learnt and expertise from previous product developments. Interview responses were mixed with respect to the presence and suitability of concept testing. It was confirmed that previous experiences and lessons learnt were fed into design decisions. User field tests during later stages (testing and validation) were mentioned to have served the purpose of concept tests. The usefulness of user feedback at this stage was also questioned, in contrast to rather introducing a more complete product at a later stage. Nonetheless, it was perceived that a large disparity existed between how users first envisaged the product at this early stage, versus how they experienced the final delivered product during later stages. It was mentioned that concept testing of speech technology applications with unsophisticated users poses a challenge, and that very little information would be gleaned by concept testing without a better understanding of how to conduct them in this context. With this in mind, it was however agreed that the design could have been improved with more user engagement or validation, with certain design decisions resulting in bloated or undesired features.

TABLE 2. PRELIMINARY INVESTIGATION ACTIVITY PRESENCE AND SUITABILITY OF EXECUTION
(● PRESENT AND SUITABLE EXECUTION; ○ ABSENT; ◖ PRESENT BUT UNSUITABLE EXECUTION)

Preliminary investigation		
Preliminary market investigation	Market attractiveness/potential assessment.	●
	Potential for product acceptance	●
	Competitive analysis	○
Preliminary technical assessment	Rough performance objectives	●
	Preliminary technical feasibility assessment (key risks and contingencies)	◖
	Preliminary operational analysis (e.g. scale of service)	●
Preliminary phase evaluation	Phase outputs evaluated against must-meet criteria	◖
	Go/kill recommendation and planning for detailed investigation.	◖

G. Detailed phase evaluation

The detailed phase outputs were evaluated or reviewed between the product development team and the research group management. The outputs of the detailed evaluation included an approved detailed product concept design or definition, as well as a go-ahead and planning for the development stage.

The presence of the detailed phase evaluation was confirmed across sources. Concerns were raised regarding a lack of objective evaluation or decision making. This is corroborated by findings that the evaluation was biased with regard to strategic objectives allowing technical feasibility (TTS readiness) issues to be accepted at the cost of end-user acceptance, as well as not having addressed unsuitable detailed market investigation or a lack of really understanding superior end user benefits at this stage. This is also confirmed by post project issue findings (Table 1). The detailed phase evaluation is thus found to have been unsuitably executed. The overall detailed phase activity presence and suitability of execution is summarized in Table 3.

H. Development phase user engagement and design-development iteration

Product concept designs were implemented by application and speech engineers. Previously developed technology components and platforms were employed as bases for this specific product, including previous telephony platform software and associated speech technology (e.g. TTS) proof of concept modules to complement speech based applications. Implementation of the product consisted of developing enhancements to the existing infrastructure (e.g. free user calls, missed call capability), developing the user applications (e.g. automated phone application call-flows, web site application), and developing and maturing speech technologies (TTS) for service delivery. Intensive in-house testing was conducted on all of the major product components between application designers and engineering. However, no end-user testing or design-development iteration was evident during the development stage.

The absence of user engagement during the development phase was confirmed across all sources. In one sense this can be attributed to a strategic focus on maturing technology components (TTS), preventing the feasibility of obtaining user feedback for this product feature or component. Other uncertain product features (e.g. user application features) could have been tested with users, but this was instead deferred to the testing and validation phase later on.

I. Development phase evaluation

Application designers and engineers evaluated the overall product implementation together with the research group management. In-house testing and validation was conducted to ensure that the product version at this stage was consistent with the original product definition, and that the implementation was soundly executed to desirable levels of quality. The outputs of the evaluation included an evaluation of a relatively final version of the product, as well as a go-ahead and planning for the testing and validation phase to follow.

The presence of the development phase evaluation was confirmed across all sources. Technical implementation and evaluation were strongly executed. The review of activities for quality execution is thus found to have been suitable. Concerns were raised about allowing uncertain product features to proceed without component level user feedback, driven by focus on strategic priorities. Overall evaluation of the product against must-meet criteria and the decision to proceed to the next phase are found to have been unsuitable, due to not obtaining user feedback for product components that eventually impacted on user acceptance, as corroborated by post project findings (Table 1). Strategic priorities took precedence with regard to many product development decisions, proving to be non-conducive for achieving end-user product acceptance. The overall development phase activity presence and suitability of execution is summarized in Table 4.

TABLE 3. DETAILED INVESTIGATION ACTIVITY PRESENCE AND SUITABILITY OF EXECUTION
(● PRESENT AND SUITABLE EXECUTION; ○ ABSENT; ◖ PRESENT BUT UNSUITABLE EXECUTION)

Detailed investigation		
Detailed market investigation	Detailed user needs and wants study (values, benefits, preferences)	◖
	Analyze existing system of use and economics	◖
	Winning/superior product concept definition from users perspective	◖
	Competitive analysis	○
Detailed technical investigation	Detailed performance objectives and specification	●
	Detailed technical feasibility assessment (key risks and contingencies)	◖
	Translation of market inputs into technically feasible product design or concept	◖
	Detailed operational analysis (e.g. scale of service, service delivery)	◖
Concept testing and design iteration	User validation of product concept (model or prototype as close as possible to the final product)	○
Detailed phase evaluation	Review activities for presence and sound execution	◖
	Phase outputs evaluated against must-meet criteria	◖
	Go/kill recommendation and planning for development stage	◖

TABLE 4. DEVELOPMENT PHASE ACTIVITY PRESENCE AND SUITABILITY OF EXECUTION
(● PRESENT AND SUITABLE EXECUTION; ○ ABSENT; ◖ PRESENT BUT UNSUITABLE EXECUTION)

Development		
Development phase user engagement and design iteration	User testing of key product component prototypes or mock-ups.	○
Development phase evaluation	Review activities for presence and sound execution.	●
	Phase outputs evaluated against must-meet criteria.	◖
	Go/kill recommendation and planning for testing and validation stage	◖

TABLE 5. TESTING AND VALIDATION PHASE ACTIVITY PRESENCE AND SUITABILITY OF EXECUTION
(● PRESENT AND SUITABLE EXECUTION; ○ ABSENT; ◖ PRESENT BUT UNSUITABLE EXECUTION)

Testing and validation		
User testing of final product and design development iteration	User field tests to determine preferences and product acceptance	◖
	Extended user tests with final product (gauge preference and acceptance more accurately)	◖
	Product enhancements based on user test feedback	◖
Phase evaluation	Review activities for presence and sound execution.	◖
	Phase outputs evaluated against must-meet criteria.	◖
	Go/kill recommendation for product launch	◖

J. Testing and validation: final product user testing

A final version of the product was approved for testing and validation after development had concluded, where additional in-house testing was first conducted to ensure that the product was as close as possible to the product definition and design. User field testing was conducted at various sites that had been located during previous phases. The product was introduced to users (community centre managers, community workers and community members) to gather information about service usability and areas for improvement. Various methods were used, including interviews and focus groups. Formal usability tests were not conducted due to various difficulties previously experienced in such environments [29], where actual usage data captured during usability tests, such as task completion, did not correlate with user preference responses. User field tests were followed by extended testing periods to continue monitoring usage trends and uptake, and to continue obtaining user feedback. A number of enhancements were made to the product based on feedback from user field tests and extended usage. Product usage and uptake levels were low for the majority of selected test sites, with one site making more frequent use. This isolated piloting success was found to be due to enthusiastic adoption by the service centre manager and communication officers, with younger users keen to explore new technology. The users were also literate and used text messaging rather than TTS and ASR, so the success was qualified regarding the technology strategy selected.

User preferences, acceptance and potential uptake were measured during field tests and extended usage testing, culminating in various minor and some more significant product enhancements. This was confirmed across sources, but concerns were raised that the testing was not conducted at scale or a representative level, and that positive bias was present resulting in a lack of critical evaluation. User feedback was also sporadic, attributed to the lack of a formal process for monitoring and evaluation. Uptake levels were not observed to increase significantly subsequent to product enhancements. User testing during this phase is thus found to have been unsuitable.

K. Testing and validation evaluation

Product acceptance and uptake levels were evaluated after user field tests and extended testing had concluded. Overall product acceptance and uptake levels were relatively low [30]. Various post project issues were identified (Table 1). Phase activities and outputs were evaluated, but were reported to have lacked objectivity or formality. Product acceptance by end-users was not fully addressed, as evident from overall low uptake levels. The phase evaluation is thus found to have been unsuitable. The overall testing and validation phase activity presence and suitability of execution are summarized in Table 5.

V. DISCUSSION AND RECOMMENDATIONS

A. Practices for product success

Proposition 1: Established product development phases and activities will increase the likelihood of success for developing incremental products in the ICT-for-development

Most of the established phases and activities were conducted for product development in this case, made evident by the previous results. Core issues were however identified with regard to the suitability of phase and activity execution, with many deemed unsatisfactory:

- There was a lack of in depth understanding real user benefits or needs resulting in overall low-uptake or product acceptance. User engagement across all product development stages was insufficient.
- Strategic objectives dictated a required level of technical novelty. Technical feasibility assessments throughout the process gave precedence to maturing the technology

readiness of core components, inadvertently at the cost of product acceptance by end-users.
- Overall phase evaluations, reviews and decision making were deemed to be informal and subjective.
- There was a narrow or short term piloting vision throughout the product process, limiting user buy-in and consideration for sustainable operation (e.g. scale of product delivery).

For this specific case, the combination of phase and activity presence alone did not lead to an increase in product success due to overall unsatisfactory execution. The proposition can only be supported under the assumption that established phase and activity presence together with satisfactory execution will lead to increased product success. It has been shown by Cooper [5:68] that phase and activity presence alone does not lead to overall product success. This finding is also confirmed by the results of this study for products developed in the ICT-for-development context. One can however argue that the analyzed case also required a degree a technical novelty, which may have limited the suitability or use of established practices, as detailed in [34] where it was found that established practices may not be applicable for very radical products. In addition, Heeks [15] mentions that more radical innovations targeted at the bottom of the pyramid are risky ventures, and that most innovations in the ICT-for-development context are likely to occur on a small scale (e.g. adapting or applying existing technologies).

B. Product development process user participation

Proposition 2: Established product development practices will be used for involving unsophisticated users in the development of incremental products

Users were involved during various stages of the product development process (preliminary and detailed investigation phases, and final testing and validation phase). Core issues were however flagged with regard to absent or unsatisfactory user engagement, as follows:
- The detailed market investigation did not yield an in-depth understanding of real end-user benefits or superior value, resulting in low eventual product acceptance.
- Product acceptance or potential for uptake was misinterpreted from perceived user enthusiasm during preliminary and detailed investigation.
- Concept testing was absent during the detailed investigation, preventing early user driven design refinement. This was attributed to a limited understanding of how to effectively perform concept testing of speech technology applications with unsophisticated users.
- Development phase user feedback for uncertain product features or components was absent.
- User field tests were not conducted at scale or a representative level, while positive bias also prevented critical evaluation. This could be attributed to the lack of formal usability tests due to various difficulties experienced in the past in such environments [29], where user preference tests were found to be unreliable, with no correlation between actual usage data and task completion.
- User feedback during extended testing was sporadic, attributed to lack of a formal process for monitoring and evaluation.

The proposition can only be supported under the assumption of the presence of user involvement practices together with satisfactory execution. The overall importance of stakeholder inclusion and the risk of information asymmetries are stressed by existing theory [31]. Established product development practices also suggest the involvement of users throughout the product development process [7, 32] to ensure that user benefits and superior values are determined. The case analysis results are found to strengthen established practices found in current theory, and confirm their relevance for the ICT-for-development context.

There may however simply be a lack of understanding of how to engage with unsophisticated users. This is perhaps made evident by early misinterpretation of perceived user enthusiasm, the absence of concept testing, and the lack of formal usability testing due to the unreliability of existing user preference testing methods [29]. The use of early concept testing to measure purchase intent is discussed in [32:155]. Usability testing techniques have to be adapted when working with people who are distant (e.g. cultural difference or operative gaps like literacy) [13].

C. Scoping and risk management

Proposition 3: Scoping risk can be mitigated by using planned iterations and design reviews in the ICT-for-development context

User feedback driven iteration was absent during the detailed investigation as well as development. Concept testing absence prevented early design iteration during the detailed investigation, and was due to insufficient knowledge of concept testing methods for this context. No component or prototype testing was conducted during development, specifically, novel technology components were not ready for user feedback during development, and other uncertain design elements or features were deferred for user testing in the subsequent testing and validation phase.

In general there was a large disparity between initial needs analysis and user field testing with respect to how users envisaged the product. Early user driven design feedback involving concept tests could have resulted in a more certain initial design and better understanding of real user benefits before development. Development prototype driven iteration based on user feedback could have given more certainty regarding system components and would have given users a much closer experience of the end product.

The proposition can only be supported under the assumption that design iteration will result in improved understanding of real user benefits or superior value. The case analysis findings cannot support the proposition due to the absence of design iteration. Even though it was mentioned in interviews that early design iteration and development iteration could have resulted in a better understanding of real user benefits, the data is insufficient for a conclusion to be drawn.

VI. CONCLUSION

Established product development practices have not focused on ICT-for-development projects. This study attempted to contribute towards establishing such practices through a case analysis of an ICT-for-development product development process by measuring it against established product development practices.

The analysis revealed a number of important points:

- The presence of established product development phases and activities within the project did not guarantee an increase in product success. These phases and activities also needed to be executed in a satisfactory manner, without allowing environmental factors (e.g. technical novelty, research outputs and infrastructure development) to prevent an in depth understanding of user benefits or superior value.
- The absence of established practice execution for unsophisticated user involvement, together with unsatisfactory execution of present established practices may have prevented the delivery of superior value or real benefits to users in the analyzed project. It can also be argued that there is simply a general lack of understanding of how to engage with unsophisticated users.
- The absence of early design iteration prevented an in depth understanding of real user benefits or superior value. In addition, early design iteration feasibility was impacted by the absence of known techniques for unsophisticated user testing with concept tests or rapid prototypes.

The above insufficiencies and related underperformance occurred in the context of a project that did achieve significant technology development and implementation objectives and was managed according to apparently sound procedures.

Initial steps were taken towards achieving the goal of new product development practices suitable for use in ICT-for-development projects. The presence of established product development practices was identified and it was analyzed how the absence or unsatisfactory execution of established practices led to a decreased level of overall product success.

The primary limitation of this study is that it is not possible to generalize the results to other ICT development organizations and projects. While the presence of insufficiencies in the project analyzed when compared to the practices found from new product development literature contributed to the limitation, the project was otherwise well executed and recorded to allowing useful findings to be made regarding the product development process domain. The documented results were corroborated and amplified by frank evaluation offered by project and management staff.

More research is needed to confirm the process elements required and their threshold of suitable execution for a given level of project complexity. It will be of particular interest to analyze projects that have achieved success in order to complement the results of this study, to verify the applicability of established product development practices, and to identify specific techniques and practices that increase product success for ICT-for-development initiatives.

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