

Methods and conceptual tools for success in local government information systems

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This paper considers the role of conceptual tools and systems design methodologies in developing successful ICT systems for (and with) local government. Using the case of the Water Quality Reporter system, a mobile phone data collection system intended to improve the ability of local government to collect, collate and react to water quality test results, we show how participatory design, iterative and incremental systems development, and soft systems tools (Checkland 1981; Checkland & Scoles 1991) such as rich pictures and stakeholder mapping have been used in the design and implementation process. Heek's model of design-reality gaps (Heeks 2006) is employed to demonstrate a gradual process of 'gap closure' over the course of the implementation. As a result, the current system embodies a clearer understanding of the parameters of success for information systems in local government.

At the same time, it is difficult to overstate the role of external factors in information systems success or failure. The Water Quality Reporter system is still a pilot project, supported by research funding. Unless long-term support can be mobilized, sustainability failure looms. The second part of the paper returns to the initial stakeholder mapping to discuss potential avenues for further development, with the broader goal of understanding how systems developed as research projects might become sustainable.

Introduction

Information systems (IS) analysis and development is a complex and multi-faceted process. The choice of development approaches and methods can determine the success or failure of an information system. An understanding of their appropriateness in given technical, organisational and social contexts is therefore important. In most cases, IS analysis and development approaches assume a commercial context, with system implementation driven by organisational efficiency and the ultimate pursuit of profit through competitive advantage.

By contrast, this paper discusses approaches to IS development in non-commercial or 'development' situations, with particular reference to local government systems.

The Water Quality Reporter (WQReporter) system, developed as part of a research project on water quality monitoring using mobile phones, provides an example case that is interesting for two reasons.

- First, there has been an unusually high level of engagement with external actors throughout the process, both in government and the private sector. This has initiated learning on communication and co-development in project teams that are not only interdisciplinary, but also come to the discussion with very different world views.
- Second, aware that the ICT4D space is littered with failed pilots that began life as university research projects, we began the project intending to use methods and tools from information systems design (ISD) to guide the development of a system that we hoped would succeed where others had failed.

While projects that mix research and implementation are common, few set out with a clearly articulated vision for how the two will co-exist. By interrogating the process and tools used during the WQReporter project, we show how the project has developed such a vision, and also explore implications for sustainability.

The remainder of the paper is organised as follows. In the next section, technical and socio-technical approaches to information systems design are briefly reviewed, particularly in the context of IS project failure. The background and design rationale of the WQReporter system are then presented, followed by examples of how rich pictures, stakeholder analysis and participatory methods were used as design and communication tools. The project as a whole is then analysed in

terms of Heek's model of design-reality gaps (Heeks 2006). In the final section we revisit implications for sustainability in dual-focus research and implementation projects.

Multiple Perspectives on Information Systems Development

Hirschheim et al (1996) describe multidisciplinary nature of the information systems (IS) field as a “fragmented adhocracy”, characterised by diverse theoretical perspectives. This state is attributable partly to the relative newness of IS as an area of research and practice, as well as the rapid pace of technological and societal change that has accompanied it (Clegg et al 1997). IS also occupies a difficult position between the 'hard' technical and applied sciences, and 'soft' fields such as psychology, management and organisational studies (Hirschheim et al 1996).

While multiple perspectives on information systems are necessary to understand their complexity (Avegerou & Cornford 1993), they are difficult to incorporate into a unified view of a system. The high rate of failure that has plagued IS development efforts to date – Briggs et al (2003) report that more than half of the software projects undertaken in the US fail, and Heeks (2002) suggests that a higher failure rate is likely in the developing world - has been attributed partly to this conceptual difficulty (Brooks 1987). Drawing on analyses of failed projects in the UK, Clegg et al (1997:857) additionally link failure to the limited disciplinary background of systems analysts, as “those who understand the technology tend not to appreciate the wider organizational issues, and those who have knowledge of these are often technically naive”.

Various IS development approaches have been proposed in response to the problem of information systems failure. Engineering approaches, where technical considerations are of primary importance, and socio-technical approaches, which give greater prominence to a broader range of organisational and social factors, offer two distinct paradigms for analysis and development. It is usual for methodologies to incorporate elements of both approaches, and Iivari & Hirscheim (1996) propose a continuum between the technical, the socio-technical and social approaches. The two sections that follow present the dominant attributes of the engineering and socio-technical approaches, as the end points of this continuum.

Engineering Approaches

In engineering or technical approaches to information systems development, the system is seen as a tool - Iivari & Hirscheim (1996:552) use the analogy of a hammer - that is used within an organisational or social context, but that is conceptually and functionally independent from that context. The ontological basis of the engineering approach is one of order and rationality, and the predictability of organisational change. The epistemological assumption is “objectivist” (Hirscheim & Klein 1989:1201) in that the existence of one correct and universal representation of the system, which must be discovered during the development process, is assumed. The analyst assumes the role of the technical expert, who must model the system and control its development and implementation. Users and other stakeholders who do not have a level of technical expertise are unlikely to be actively involved in the systems development process, and are viewed instead as peripheral informants for modelling, or constraints on design.

In management terms, the view of information systems development as a primarily technical activity lends itself to the application of project management methods used in engineering projects. The lifecycle model, in which there is a sequential progression through planning, analysis, design, construction and maintenance phases, was the original development process model for computerized information systems, and is still in use in various forms (Avgerou & Cornford 1993).

The lifecycle model has been criticised as inflexible and unrealistic, with each later phase being contingent on the full and correct completion of the previous phase. However, it remains a simple and manageable starting point for the technical dimension of systems development (Avgerou &

Cornford 1993) provided the ontological assumption of predictability and consistency in external factors can be maintained.

More recent developments in the field of software engineering, which concentrates on rigour in system specification, development and testing methods, have explored iterative and incremental alternatives to the lifecycle model. Methodologies such as the Rational Unified Process (Kruchten 1999) and the Spiral model (Boehm 1998), combined with an increasing acknowledgement of the importance of user-centred design originating in the field of human-computer interaction, represent tenable alternatives within the engineering approach. However, as information systems are frequently intended to enable organisational change (Clegg et al 1999), it is doubtful whether they are most effectively represented as technical tools removed from their organisational and social context. Most modern approaches in software engineering recognise this, but resolve the issue by limiting the scope in which they work. In so doing, they risk leaving aside vitally important contextual factors.

Socio-technical Approaches

Socio-technical approaches to information systems development view the technical component of a system as inseparable from the organizational and social context in which it will be used. Rather than building a tool independently of its context, socio-technical systems development is a process of “calibrating work and tools to each other” (Schulman et al 2007:549). The development process is not led or controlled by the technical system, but instead aims to achieve a balance between technical and social/organisational considerations (Mumford 2006), and through this a “multidimensional process of social change” (Avgerou & Cornford 1993:150) in pursuit of stakeholder goals.

The inclusion of the social dimension, which “follows the laws of the human sciences, and is purposeful” (Olerup 1989:48) extends the ontological and epistemological bases of the socio-technical approach beyond the positivist “functionalism” (Hirscheim & Klein 1989:1201) of the engineering approach, which is only applicable to the technical system. The process of socio-technical systems development instead assumes the form of action research (Mumford 2006), recognising that information systems development is a process of (sometimes unpredictable) organisational change, experienced by stakeholders in different subjective ways (Avgerou & Cornford 1993). Full stakeholder acceptance is unlikely unless these subjective experiences are recognised and validated in the development process. Accordingly, the analyst acts not as an expert (although some technical expertise may be required in practice), but as a “facilitator” (Iivari & Hirscheim 1996:555) of organisational and social change processes led by participants themselves.

Blake and Tucker (2006) observe that the multiple cycles of planning, acting and evaluating that characterise action research can be translated appropriately into an iterative and incremental software development process. Both engineering and socio-technical approaches have come to recognise the value of iterative development, where each iteration is informed by experiences from previous iterations. However, the socio-technical approach is explicit in its consideration of reflexive “adaptation” (Mumford 1995:7) through shared learning among stakeholder groups, which almost forces an iterative process (Gasson 1998).

The principle of participation, too, is present in many IS development methodologies, but is articulated particularly strongly in the socio-technical approach. In keeping with the ethical assertion that those who will be affected by a system should to some extent be able to guide its development (Mumford 1995), participation aims to give voice to stakeholders or stakeholder groups, as well as facilitating the process of shared experiential learning. Participation is also seen as important on a purely pragmatic level: it is often the only way to uncover vital information about the functional and political nature of organisations (Avgerou & Cornford 1993).

As a single philosophy, the socio-technical approach has not been widely adopted in the practice of information systems development (Avgerou & Cornford 1993:161). Mumford (2005) contends that this is partly to do with the prevailing climate of 'downsizing' in the business environment, which remains primarily concerned with maximising profits rather than with employee satisfaction. In the development space, too, there is a tendency to conflate information systems with improved efficiency – by implication, economic efficiency. Avgerou (2000) calls this the “techno-economic rationality of western modernity”.

Some of the tenets of the socio-technical approach have also proven difficult to translate into practice. Participation, particularly in situations where there is a power imbalance, is too often a veneer on decisions that favour a dominant group (Heeks 2006). While the socio-technical approach acknowledges the influence of issues of power and political control on information systems development, it does not provide an effective way to manage power imbalances (Hirscheim and Klein 1994). Socio-technical methodologies such as ETHICS (Mumford 1995) also assume that job rules are flexible, and can be redesigned alongside the information system. This can be difficult to achieve in many companies, and even more so in the public sector.

System design in research projects

Information systems design undertaken as part of a research project has different constraints to commercial projects, as well as different motivations. Time lines are longer, and the kinds of projects undertaken are different. Novel, 'risky' projects are more likely to receive support, as are systems with an explicit social (rather than economic) motivation. Large, complex and mission-critical systems are less attractive, for both operational and ethical reasons. Furthermore, learning and knowledge production in research projects are an end in themselves, rather than simply informants to system design. This is true for both engineering and socio-technical approaches, despite differences in scope, ontology and epistemology.

While recognising these differences, there are still significant areas of commonality between research and system design activities. Both seek to describe the context of the system in a structured way, whether according to a technically-focused engineering framework or a broader socio-technical one, and have established methods to do this. Both also recognise the need for evaluation against an agreed set of criteria. In the early stages of a project where the technology and/or application area are substantially unexplored, a research group may be better placed than a commercial company to lead development (Rivett and Tapson 2009). Conversely, as the system matures, commercial support is key to sustainability in the long term. Description and evaluation work done in the research phase should serve as a guide in this process, and perhaps help to resolve some of the practical issues faced by socio-technical approaches.

The WQReporter System

Background

The WQReporter system is being developed as part of Aquatest, an international research programme to develop a low-cost water test for the developing world. Initiated in 2006 under the EU sixth framework programme, the project secured funding from the Gates Foundation in 2007 for the period 2008-2011. The project consortium includes universities in the UK and US, the World Health Organization (WHO), two US-based non-profits, and the Spatial Data Management group at the University of Cape Town (UCT).

UCT became involved in the Aquatest project to investigate the potential uses of mobile technologies in drinking water quality monitoring – specifically in communicating the results of the Aquatest low cost water test. During the initial EU funding stage, this involved developing and obtaining feedback on a prototype system. When funding for a larger project was obtained, the

prototype was taken and developed into a full operational system, which is currently being field-tested in South Africa. As a mobile data collection system, the development of WQReporter built on earlier work at Cell-Life (www.cell-life.org), which develops IT systems for HIV management. Cell-Life started in 2001 as a research collaboration between staff of the Engineering Faculty of the University of Cape Town (UCT) and the Cape Peninsula University of Technology (CPUT), becoming a separate non-profit in 2007.

Research Design

Development of the WQReporter system is undertaken as a participatory action research, with functional prototype software being developed, used and evaluated in iterative and incremental process. The long implementation timeline has allowed us to make longitudinal observations, working with the same people for several years. Perhaps more importantly, longer timelines are essential to the development of relationships and trust. Particular emphasis is placed on supporting evaluation and design by software users themselves. To do this, we are using unstructured narrative interviews (“tell me a story of how you have been using the system”) and actively and opportunistically soliciting input into the concept and design of software features.

There are currently four local municipalities participating in the project, with about 35 municipal foremen, environmental health professionals and community borehole caretakers reporting water test results on a regular basis. One municipality is located in the Northern Cape province of South Africa, with other three are in the Eastern Cape. Both provinces are predominantly rural.

System Description

- The **Water Quality Reporter cellphone application** provides a simple structured data collection form on the user's phone. The user navigates through the form, responding to questions such as 'where was the sample taken?' or 'what was the reading for turbidity?'. Once data about the sample has been entered into the phone, the user sends the completed form over GPRS to a central server.
- As an alternative reporting method, the user can send a **Water Quality Report SMS** in a predefined format – for example 'H2S 123456 clear 78901 1' to record the result (clear) of an H2S tests, where 123456 is the serial number of the test, 78901 is the identification number of the sample point, and 1 is the number of days since the test was taken.
- The **incoming message manager** receives incoming sample data and performs basic verification and data integrity checking before storing the incoming data in the database.
- The **samples database** stores all data collected using the cellphone application.
- The **SMS notification and feedback subsystem** can be configured to send various messages via SMS when sample data is received. Currently, the person sending in the sample data receives a confirmation message when it is successfully received, as does the person with overall responsibility for water quality monitoring in the WSA. In case of a result outside of acceptable operational parameters, an SMS alert is also sent.
- The **web reporting interface**, currently limited, provides a data viewer and system configuration functionality.
- **External system integration** provides automatic data upload to EWQMS

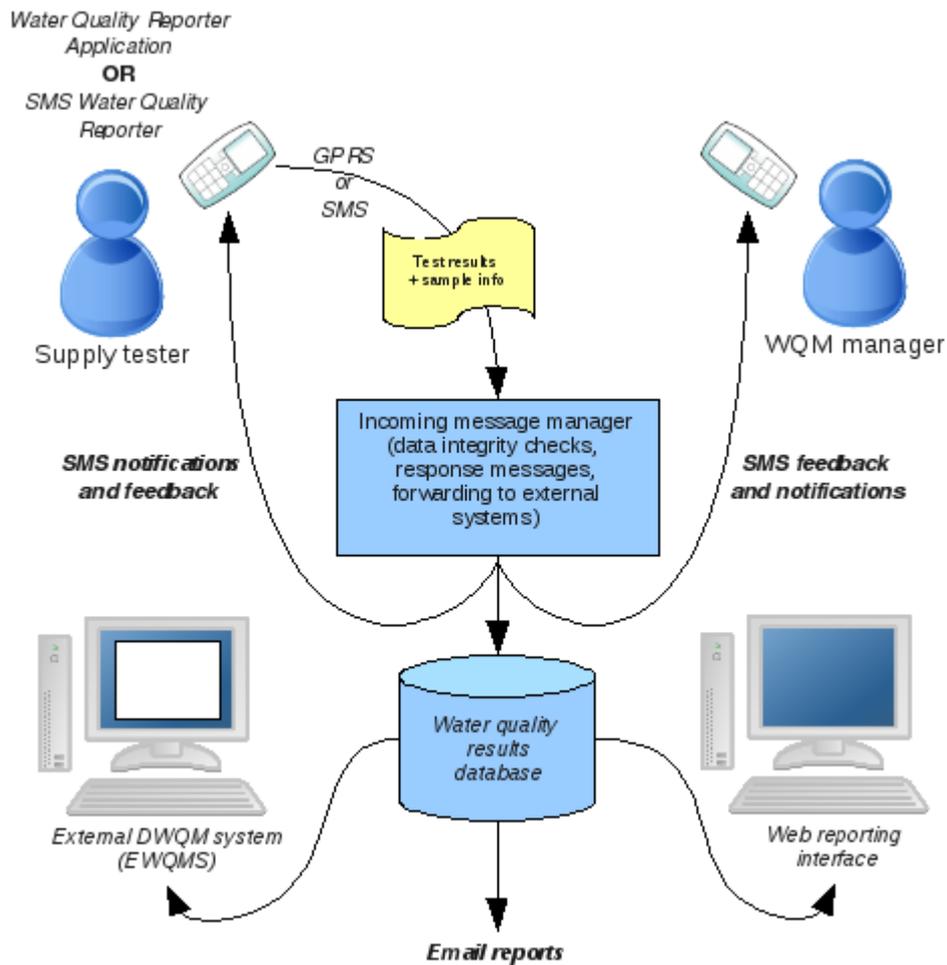


Figure 1: WQReporter System Diagram

Stakeholder Analysis

Bailur (2007) identifies two reasons for undertaking stakeholder analysis in ICT4D projects. In terms of research and evaluation, understanding stakeholders and how they relate to the project enriches participants' understanding of the problem situation. More practically, stakeholder analysis, from which can be derived a plan for stakeholder management, can contribute to buy-in at the start of the project and sustainability in the long term.

Soft systems introduces stakeholder analysis as part of the CATWOE checklist (Checkland and Scholes 1989), from which is derived a *root definition* for a *human activity system*. For the Aquatest project, a CATWOE checklist for the human activity system of monitoring water quality in a municipality might look as follows.

Customers	Municipal water and environmental health personnel of [the municipality], who are struggling to meet their commitment to monthly water quality monitoring at all supplies.
Actors	<ul style="list-style-type: none"> ● Community-based organisations or individual caretakers responsible for supply management, who may conduct some monitoring independently ● Municipal officers who are legally bound take monthly samples and react to results ● National Department of Water Affairs, to whom results are reported and who also provide support to struggling municipalities ● Mayor and municipal leadership - problems with water supply will hurt their political reputation
Transformation Process	Water samples taken by the municipal department with a responsibility for water quality monitoring are transformed into lab results in digital form and communicated back to municipal officials, who should assess the situation, respond appropriately and record the action taken for reporting to the mayor, the community and ultimately to DWAF.
World View	Monitoring is a requirement for providing safe water. Resource limitations are a major challenge in South African municipalities, and are likely to remain so.
Owner	Municipal department with responsibility for water quality
Environmental Constraints	<ul style="list-style-type: none"> ● Limited infrastructure – unreliable telecommunications, power outages, poor roads. ● Limited resources – money, trained people, vehicles ● Legislated requirement for lab samples regardless of whether an alternative field test is available

Table 1: CATWOE checklist (Checkland & Scholes 1989) for drinking water quality monitoring

From this, we could derive the following root definition:

The department responsible for water quality monitoring at the municipality owns a system which, under given infrastructure, resource and funding limitations, transforms water samples collected at supplies into lab results captured in digital form, the transformation being carried out by the tester, municipal employees and the lab and affecting communities, the political image of the mayor and municipal leadership and the oversight capabilities of DWAF. The world view of the system recognises that monitoring is a requirement for providing safe water, and that resource limitations are a major challenge in South African municipalities, and are likely to remain so.

The advantage of this method is that it captures stakeholders as part of the wider system context, including vitally important external factors (world view and environmental constraints) under which the transformation takes place. However, there is also a role for a more focused stakeholder analysis. In the case of the WQReporter system, the development of an importance/influence matrix for stakeholders was particularly valuable in identifying the role of the researchers as high-importance, high-influence stakeholders in the project. This came about because the first version of the matrix – shown in Figure 2 – did not include researchers, but only those who would be considered in the problem situation of water quality monitoring as set out by law.

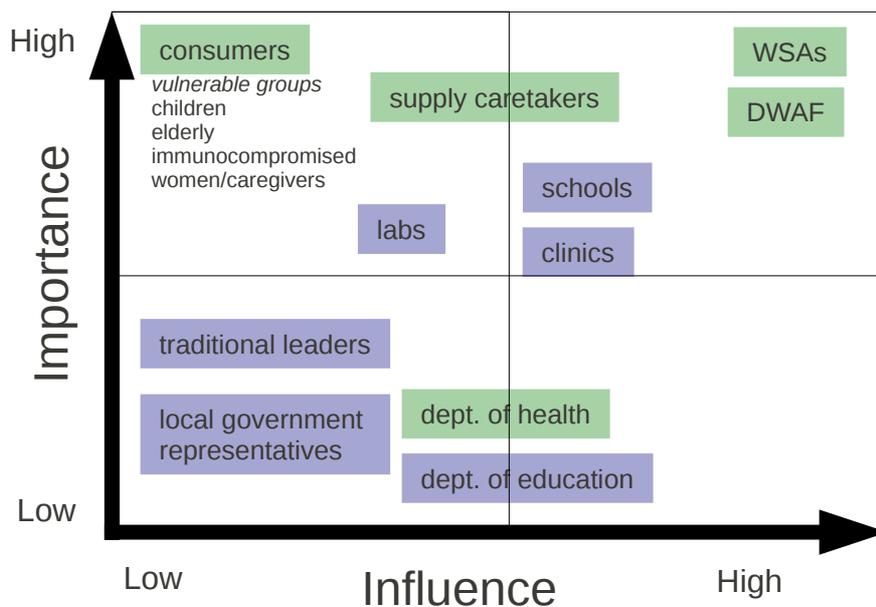


Figure 2: Stakeholder importance/influence in drinking water quality monitoring

The stakeholders identified here include the following:

- Consumers, with vulnerable groups as a subset that must also be provided for.
- Supply caretakers, who are local residents provided with a stipend to oversee a village supply.
- Water Service Authorities (WSAs), who have legal responsibility for ensuring that water is supplied to consumers in their area, and for ensuring that water quality monitoring takes place. WSAs are local, district or metro municipalities depending on the area.
- The Department of Water Affairs and Forestry (DWAF), the regulatory agency for water services to whom water quality monitoring results are reported. As the 'sector leader', DWAF also provides support to WSAs struggling to fulfil their function.
- Labs, who currently test samples taken at the source, and would be affected by the introduction of a field test.
- Schools and Clinics, who are responsible for ensuring safe water supply to their service users.
- Traditional leaders, particularly in rural areas. Traditional leaders were considered as low-influence, low-importance stakeholders because the system was primarily concerned with supporting municipal officials at WSAs rather than working directly with communities, but would likely have much higher importance and influence in certain areas.
- Local government representatives, including the mayor and the municipal council.
- The departments of health and education, who have a legally constituted oversight role in terms of ensuring service users are provided with safe water at schools and clinics. The department of health also has a responsibility for environmental monitoring, which may include water quality monitoring.

On reflection, we realised that an accurate assessment of stakeholders included not only ourselves as the researchers directly involved in the project, but also other groups within the Aquatest consortium. The funder for the research, the Bill and Melinda Gates foundation, also has a

particular perspective, and needs to be included. Our revised stakeholder importance/influence matrix is shown in Figure 3.

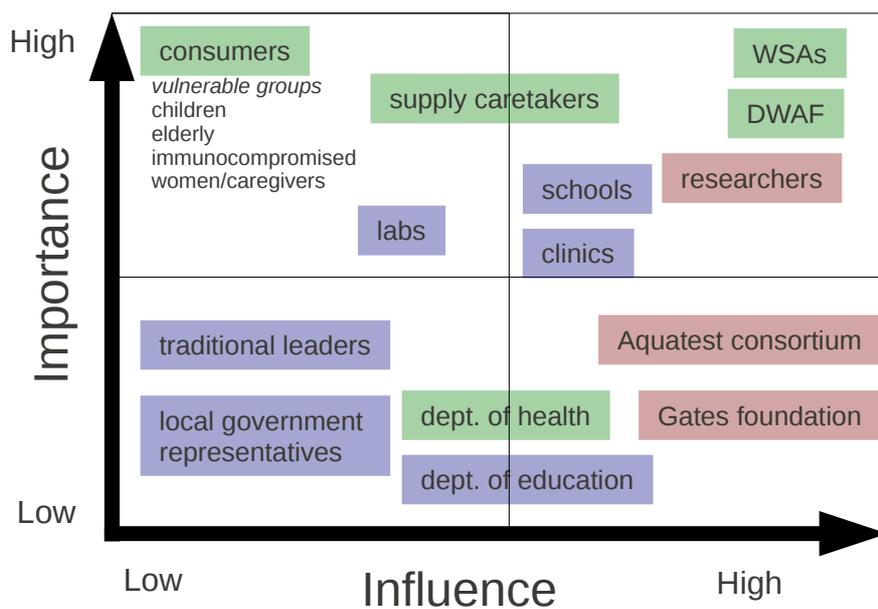


Figure 3: Stakeholder importance/influence matrix for the WQReporter project

The additional stakeholders in this version are:

- Researchers, referring specifically to the research team at the University of Cape Town.
- The Aquatest project consortium, primarily concerned with the development of a new water test.
- The Bill and Melinda Gates Foundation, who fund the Aquatest project as a whole.

Our experience in the project to date has been that these three stakeholders have in fact required by far the most 'management'. In the water quality monitoring problem situation, roles and responsibilities are relatively well defined, not least in legislation. While these may vary in practice – in particular, different municipalities have different local arrangements regarding water supply, with some using Environmental Health Officers to collect samples where other make this the responsibility of the Water Services department, the supply caretakers or even private companies contracted to run the water infrastructure in certain areas – there is clearly agreement on the desired information flow. With researchers, the broader consortium and the funder, roles and spheres of influence are continuously negotiated, and the information system invariably reflects this. In our project, for example, there were discussions about how far it was possible to quantify and extrapolate the impact of the information system on health outcomes. We also worked on a mobile image processing system (see Loudon et al 2009) that, while technically ingenious, was intended to tie our work more closely to the water test development rather than to satisfy any particular need expressed by South African stakeholders.

Stakeholder analysis has proved valuable to both the research and system implementation components of the WQReporter system. In terms of research, mapping out stakeholder helped us to understand not only the information flow, but also the possible avenues for sustainability should the system endure beyond the research project. It has also helped us to broaden our understanding of potential informants, thus improving triangulation of sources. The system implementation has benefitted from a better understanding of stakeholder needs, which has allowed us to define more clearly what kind of data is important to each stakeholder. The exercise also prompted the

researchers to seek appropriate permission from municipal management and DWAF, and to endeavour to keep stakeholders informed of the progress of the project.

Rich Pictures

Rich Pictures, another well-known soft systems technique for capturing the problem situation, were used in both the early feasibility/problem identification stage and later in the project – in modified form – as a communication tool for diverse groups.

Early in the project, a series of interviews were conducted around the theme of information needs in water quality monitoring, specifically in the large rural municipalities of the Eastern Cape province. The rich picture shown in Figure 4 was prepared from data collected in these interviews.

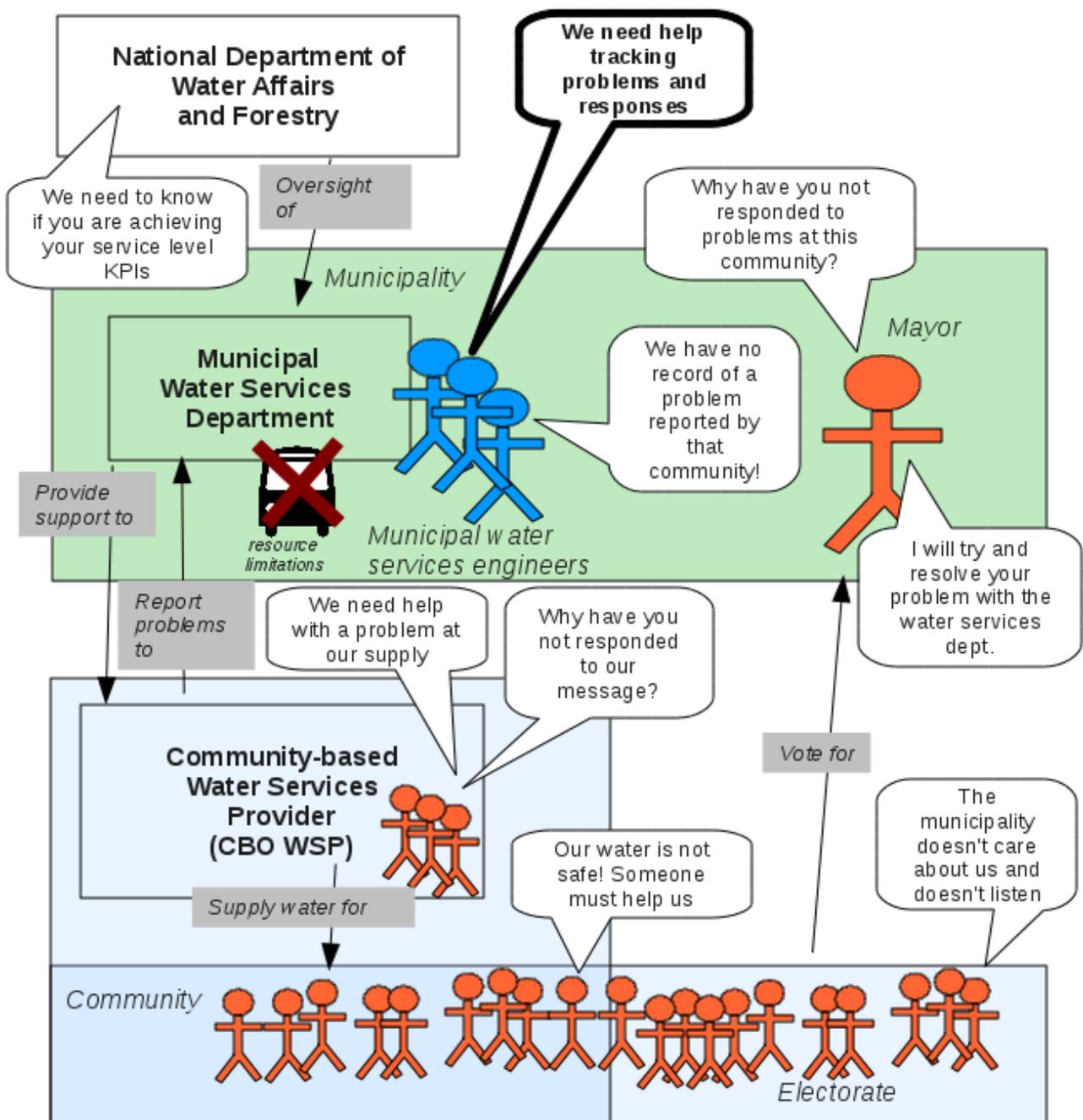


Figure 4: Rich picture derived from interviews on water information needs

The most striking thing about this picture is that direct measurements of water quality don't appear at all. When asked to discuss information needs and communication – specifically with a view to developing a new system, interviewees cited problem tracking, accountability of elected officials, provision of support to community-based water service providers (or supply caretakers, who are in an equivalent position), and oversight by DWAF. This does not mean that water quality information is important, but, as the rich picture shows, it is not the highest priority application of ICTs. While our research area was fixed by virtue of the nature of the funding, this learning was valuable and well codified in the rich picture.

Further, rich pictures are understood in soft systems as a collaborative effort. We actually found them too time-consuming to use in this way. This does not negate their value in communicating a complex problem situation where more time is available – for example, they have been valuable in developing a shared understanding within our research group, and with international partners. In Figure 5 and Figure 6, simplified and modified diagrams, nonetheless recognisable as related to the concept of a rich picture, show other versions developed to communicate specific points. In Figure 5, other systems already in place in the South African water sector are located at specific organisational levels, with the role of a cellphone system suggested for discussion. Figure 6 explains the feedback loop aspect of the WQReporter system for a non-technical audience.

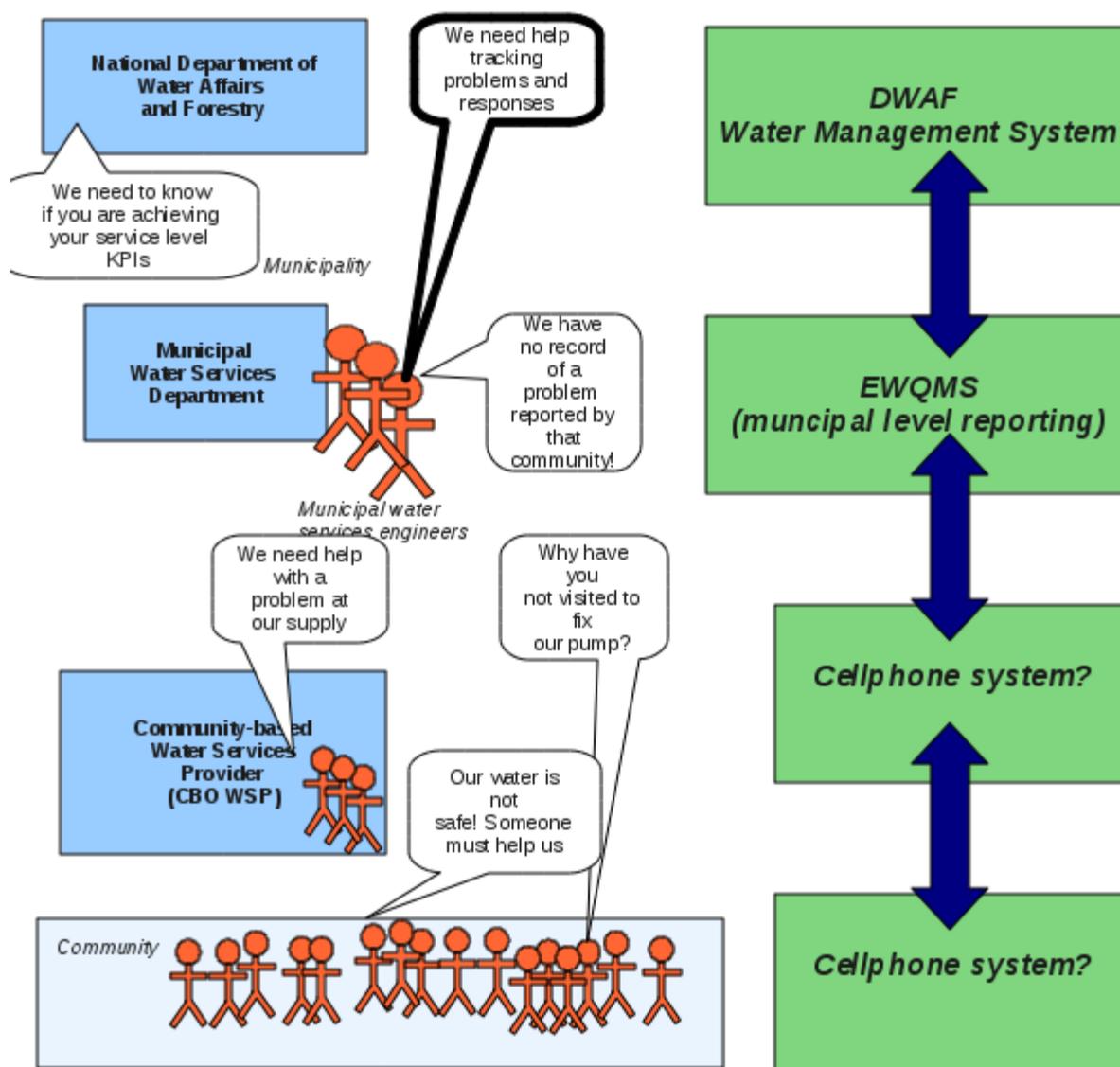


Figure 5: Modified rich picture showing existing systems

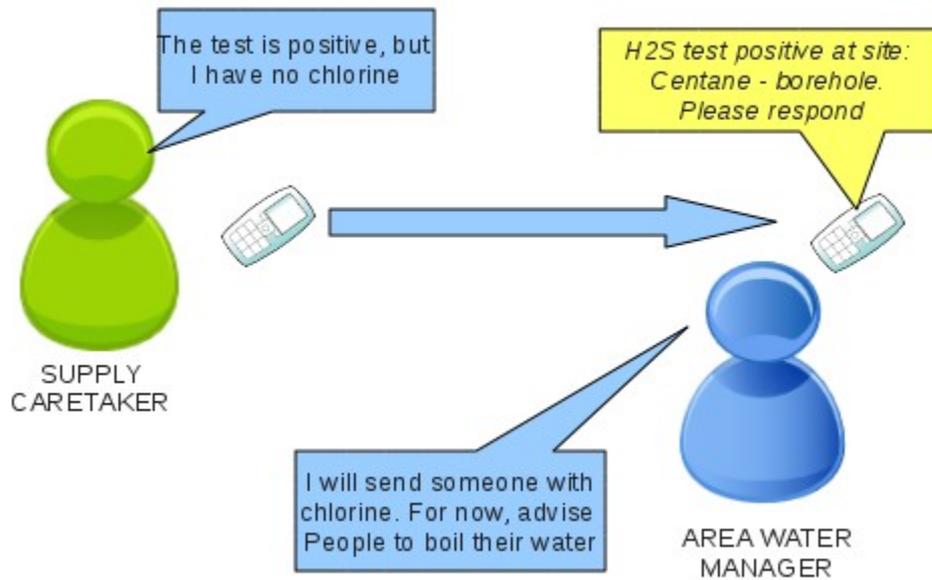


Figure 6: Modified rich picture showing feedback loop for a non-technical audience

Analysing WQReporter using design-reality gaps

WQReporter was developed using an iterative and incremental approach, termed evolutionary prototyping (Carr & Verner 1997), was chosen because software support to water quality monitoring at local level has not previously been explored, and requirements were poorly defined initially. Implementing WQReporter in the different municipalities over several iterations was equivalent to a process of gradually closing “design-reality gaps” (Heeks 2006), and was a key driver of system success.

In Table 2, the design-reality gaps that existed at the beginning of the project (January 2008) will be described. Some gaps remain, but for those that have been reduced, the steps taken to close the gap have been included.

Dimension	Design	Reality	Gap closure actions
Information	The initial system design made provision for access to information through a web interface, and also intended to provide automatic upload to DWAF's regulatory system	Municipal managers seldom access the web in their daily work – often, they are on the road. The most convenient way to reach them is through their mobile phones. Much of the data collected with field tests is operational – for the municipality's own use – and does not need to be communicated to DWAF.	SMS notifications of submitted reports replaced a web interface in the initial system, and will be kept as a priority. In each iteration where automatic upload to DWAF was considered, it was pushed out to the next iteration, and is now very low priority by default.
Technology	Internet access and reliable electricity at municipal offices was assumed. Initially, municipal workers were assumed to have phones suitable for installing the Java application	Internet access was unreliable in all municipalities at some stage, with many individuals accessing the web using very slow mobile connections. Further, a lack of clarity on replacement policies for lost or stolen phones meant that many did not have their municipality-issued phone, but rather a basic non-Java model.	The SMS notification system mentioned above is both more appropriate and more technologically feasible for slow or unreliable connections. We moved gradually from a policy of providing a compatible phone to those who lacked one to providing the same standard phone to all participants.
Processes	Because they stem from legislation at national level, processes were assumed to be similar across provinces.	Although part of national government, DWAF operates through provincial offices with significant variability in the kind of support they provide to municipalities, and the priority accorded to monitoring.	The decision on how to use the system was lead by the municipalities themselves.
Objectives & values	The overriding objective of municipal water services is to improve drinking water quality.	There are many competing objectives in municipalities, both within the water function and with other functions performed by the same personnel.	The decision on whether to use the system was led by municipalities, as is the decision on how to use the data collected, which is sent to them as a monthly report but not reported on to other stakeholders.
Staffing and skills	Training was prepared expecting staff to be familiar with basic phone functionality such as SMS, but not with applications	There is great variability within and between municipalities. Most young people living in large towns are familiar with applications on their phone, while some older or rural staff are not even familiar with SMS	Training was kept very short (maximum 2 hours), followed by individual sessions at the user's place of work that allowed certain aspects to be revised if necessary.

Management systems and structures	The manager of the sampling programme was the person from whom initial permission was sought, as was assumed to be responsible for all staff involved in sampling.	Staff from other departments or even other levels of government may also be involved in sampling. Permission from the elected local council is necessary to carry out a research project in any municipality.	Permission was sought from council or appropriate representatives, often facilitated by municipal managers. Enforcement of regular sampling (e.g. reminders, requests for a sample) was not built in to the system to allow for variability in management structures.
Outside world	The EWQMS system, provided by DWAF as a tool for municipalities to enter compliance data, was assumed to be universally accepted and used.	EWQMS is not used in some municipalities, who may use DWAF's alternative system, report manually or regularly, or be non-compliant.	Automatic integration with EWQMS has been postponed, as this could lead to accusations of one system being favoured over alternatives.

Table 2: Design-Reality Gaps (Heeks 2006) and gap closure actions

Table 2 shows that the implementation of WQReporter became more successful with time. Using the gap “archetypes” developed for health care information systems (Heeks et al 1999) - rationality-reality gaps, private-public gaps and country context gaps – part of this success can be attributed to the fact that the system was developed in-country, and with specific design considerations for the public sector. Rationality-reality gaps, too, may be narrower in basic data collection. Water quality data collection is undertaken following clearly defined processes, which the new system did not change.

The design-reality gaps model is useful for its broad scope, taking in several different dimensions while also forcing the analyst to start from the assumption that design and reality do not match up. In terms of the research project, repeating the analysis at several points in time is a good way of tracking change. This fits well with the iterative and incremental approach, which in itself has been responsible for positive outcomes by allowing gap closure actions to develop over time.

Conclusion

Socio-technical design tools have proved a valuable resource in both the design and implementation of the WQReporter system, as well as providing guidance on future channels for achieving sustainability. The applied research project for which the system was created has used the tools to improve researchers' understanding of the system context as well as to communicate in a diverse project team. Stakeholder analysis in particular has helped to locate stakeholders related to the research project relative to the problem situation.

Soft systems as originally constituted is a time-consuming approach, which is highly challenging in the time-scarce local government environment. We have found that some tools are most appropriate for use within the research team, where dedicated time is available to go through the process. The single most valuable tool for eliciting feedback from system users is prototyping, regardless of whether a working or demonstration prototype is used.

Compared to a commercial project, system implementation as a research project can take a socio-technical perspective more easily. Time is less critical, and understanding the system in context is an end in itself. This suggests a plausible synergy between researchers and the commercial or in-

house teams who are vital to ensuring sustainability beyond the research phase, and ultimately to determining the system's success.

References

- Avgerou, C., 2000. Recognising Alternative Rationalities in the Deployment of Information Systems. *EJISDC*, 3(7), 1-15.
- Avgerou, C. & Cornford, T., 1993. *Developing Information Systems: Concepts, Issues and Practice*, Macmillan.
- Avgerou, C. & Street, H., 2000. Recognising Alternative Rationalities in the Deployment of Information Systems. *EJISDC*, 3(7), p.1-15.
- Bailur, S., 2007. Using stakeholder theory to analyze telecenter projects. *Information technologies and international development*, 3(3), 61–80.
- Blake, E. & Tucker, W., Socially Aware Software Engineering for the Developing World. *Paper in IST-Africa 2006 Conference Proceedings*, P. Cunningham and M. Cunningham (Eds), IIMC International Information Management Corporation, ISBN, p.1-905824.
- Boehm, B.W., 1988. A spiral model of software development and enhancement. *Computer*, 21(5), p.61-72.
- Briggs, R.O., De Vreede, G.J., et al., 2003. Special Issue: Information Systems Success. *Journal of Management Information Systems*, 19(4), p.5-8.
- Brooks, F.P., 1987. No Silver Bullet. *IEEE Computer*, 20(4), p.10-19.
- Carr, M., & Verner, J. (1997). *Prototyping and Software Development Approaches*. City University of Hong Kong. Retrieved January 8, 2008, from www.is.cityu.edu.hk/Research/WorkingPapers/paper/9704.pdf
- Checkland, P., 1981. *Systems theory, systems practice*, Chichester: John Wiley.
- Checkland, P.B. & Scholes, J., 1989. *SSM in Action*, Chichester, John Wiley & Sons Ltd.
- Clegg, C., Axtell, C., et al., 1997. Information technology: a study of performance and the role of human and organizational factors. *Ergonomics*, 40(9), p.851-871.
- Gasson, S., 1998. Framing design: a social process view of information system development. In *Proceedings of the international conference on Information systems*. Helsinki, Finland: Association for Information Systems, p. 224-236. Available at: <http://portal.acm.org/citation.cfm?id=353053.353073&coll=GUIDE&dl=GUIDE&CFID=19308192&CFTOKEN=57847643> [Accessed March 8, 2008].
- Heeks, R., 2002. Information Systems and Developing Countries: Failure, Success, and Local Improvisations. *The Information Society*, 18(2), 101-112.
- Heeks, R., 2006. Health information systems: Failure, success and improvisation. *International Journal of Medical Informatics*, 75(2), 125-137.
- Heeks, R., Mundy, D. & Salazar, A., 1999. *Why Health Care Information Systems Succeed or Fail*, Manchester: Institute for Development Policy and Management, University of Manchester. Available at: <http://unpan1.un.org/intradoc/groups/public/documents/NISPAcee/UNPAN015482.pdf> [Accessed January 11, 2008].
- Hirschheim, R. & Klein, H.K., 1994. Realizing Emancipatory Principles in Information Systems Development: The Case for ETHICS. *MIS Quarterly*, 18(1), 83-109.

- Hirschheim, R., Klein, H.K., & Lyytinen, K., 1996. Exploring the intellectual structures of information systems development: A social action theoretic analysis. *Accounting, Management and Information Technologies*, 6(1-2), p.1-64.
- Iivari, J. & Hirschheim, R., 1996. Analyzing information systems development: A comparison and analysis of eight is development approaches. *Information Systems*, 21(7), p.551-575.
- Kruchten, P., 1999. *The Rational Unified Process*, Pearson EducationDeutschlan.
- Loudon M, Ajmal T, Rivett U, de Jager D, Bain R, Matthews R, Gundry S: A 'human-in-the-loop' mobile image recognition application for rapid scanning of water quality test results, EISE 2009. Available at: www.ukinit.org/eise09
- Mumford, E., 1995. *Effective systems design and requirements analysis: the ETHICS approach*, Macmillan, Basingstoke.
- Mumford, E., 2006. The story of socio-technical design: reflections on its successes, failures and potential. *Information Systems Journal*, 16(4), p.317-342.
- Olerup, A., 1989. Socio-technical design of computer-assisted work: a discussion of the ETHICS and Tavistock approaches. *Scand. J. Inf. Syst.*, 1(9), 43-71.
- Rivett U., Tapson J. 2009: The Cell-Life Project: Converging technologies in the context of HIV/AIDS, *Gateways International Journal of Community Research and Engagement*, Vol 2(2009); 82-97
- Schulman, J., Kuperman, G.J., Kharbanda, A., et al., 2007. Discovering How to Think about a Hospital Patient Information System by Struggling to Evaluate It: A Committee's Journal. *Journal of the American Medical Informatics Association*, 14(5), p.537-541.