Designing sustainable sanitation: Involving design in innovative, transdisciplinary research

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This paper introduces an innovative pilot project where an alternative system of sanitation to capture, treat and reuse urine in agricultural trials is being undertaken in a university setting. The paper outlines the emerging theory and practise of Transition Management (TM) and identifies a lack of attention to the end-user in transition experiments to date. This project situates design as a core component in the social process of transitioning to a novel system of sanitation. Students across two design schools developed visual prototypes to introduce the project to the target audiences, which were tested during a pre-pilot installation. Initial results support the guiding hypothesis that design has a critical role to play in facilitating social learning in system innovation.

Keywords: Sustainable sanitation, Design research, Design education, User participation, Graphic design

The biophysical, socio-cultural and technological problems that design needs to perceive, engage with and respond to, are growing in complexity and scope. In Australia, water, energy and now food security are significant and emotive issues in the public imagination with complex environmental, political and social dimensions. At the same time, unsustainable resource use and waste generation is embedded in everyday habits, which remain relatively undisturbed. Ulrich Beck (1995) has argued that environmental threats disenfranchise the senses. While big stories (and their empirical symptoms) enter our lives at an abstract level, nothing has really changed for the senses in everyday life. These insights help to delineate an ambitious agenda for design research that: discerns problems where none might be perceived; generates criteria in response to these problems; designs options in response to criteria; and tests options via social engagement and participation. This paper tells the story of an innovative, transdisciplinary pilot project that adopts this agenda to explore the agency of design in supporting the transition to sustainable sanitation.

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The Transitioning to Sustainable Sanitation Futures project (aka the 'Funny Dunny' project)[1] is a two-year action research project involving the installation of an alternative system of sanitation to collect and treat urine at the University of Technology in Sydney (UTS), and reuse it in agricultural trials at the University of Western Sydney (UWS). The project is premised on the potential value of urine as a substitute for phosphate rock, the primary component of chemical fertilisers used in agricultural food production. Mined phosphate rock is a rapidly depleting, finite mineral resource that underpins global food security (Cordell, Drangert, & White, 2009). At the same time, phosphorus is widely understood as an environmental pollutant, which is costly to manage and treat. The key aim of the project is treat urine as a resource by undertaking a trial to reuse urine in food production and subsequently close the phosphorus loop locally. Yet to capture, value and reuse urine in this way requires a significant transformation in how we think about sewage, as a resource rather than waste product. So while the project presents many technical and regulatory challenges in implementing sustainable innovation, it also presents social and cultural challenges where embedded perceptions of sewage as a waste product, become difficult to transform. From its inception, the 'Funny Dunny' project employed design as a core component in facilitating the socio-cultural process of transitioning to a new and unfamiliar system of sanitation. The project was attuned to a lacuna in research regarding the social experience of technical change as researchers found there has been limited user participation in experiments trialing alternative sanitation options to date. This provided a rich point of entry for design, which was perceived as an important enabler of this missing participation. Visual communication design concepts were generated that dealt precisely with human touch points in the new system, and were selected for installation during the trial by a transdisciplinary research team. Design's generative impulse was thereby a key enabler of progress regarding the collection of social data in the project, and contributed significantly to its experimental intent. This raises intriguing questions about the role that design could play in transdisciplinary research oriented towards complex system innovation more broadly.

The problem space of the project can be defined using Geels (2002) multi-level perspective on technological transitions. At the level of the 'landscape' is the threat of climate change on water and food security and the emerging story of Peak Phosphorus (Cordell et al., 2009). These macro level issues bring into sharper relief the irrationality of centralised, water-based sanitation. The 'socio-technical regime' (Geels, 2002) of sanitation at the meso level is characterised by a complex 'patchwork' of technologies, institutions, infrastructures and social conventions of practise that have evolved over the last century into a highly path dependant system (Fam, Lopes, Mitchell, & Willetts, 2009). This project is driven by the motivation to trial radical innovation at the 'niche' level in anticipation of a landscape shift and in the understanding that new landscape pressures can create openings for innovation at

all levels of the system (Rip & Kemp, 1998). One of the overarching goals of the project is to reveal, respond to and learn to manage issues arising from the installation of new systems of innovation – in this case, urine diversion.

1 Background: transition management and design

The complexity of facilitating system innovation relates to the fact that transformation of large scale infrastructural systems such as sanitation cannot be brought about through technological innovation alone but requires mutually reinforcing institutional and socio-cultural transformations (Geels, 2005). One of the approaches that advocate this philosophy is the recently emerging theory and practise of Transition Management (TM). TM is a strategy based on complex systems thinking which envisages steering of evolutionary processes through a means of 'learning by doing' (Kerkhof & Wieczorek, 2005). Often highlighted in TM is the importance of formulating a space for learning by a range of stakeholders including policy makers, scientists and technologists. What is rarely distinguished in TM's vague characterisation of stakeholders is the importance of encouraging learning by the user of the new technology and consideration of changing habits of practise that need to occur throughout the domestication process (Lie & Sorenson, 1996). As Shove has critically noted, the emphasis on innovation in TM has an implicit focus on technical systems and infrastructures of provision and supply (Shove & Walker, 2007) with the importance of considering habits of practise often overlooked (Shove & Walker, 2010).

Creating an environment for learning to occur in an intense and deliberate fashion is therefore of critical importance in the process of facilitating innovation. TM strongly advocates multi-stakeholder involvement in inducing system change and emphasises the importance of devising explicit learning goals for transition experiments (Kerkhof & Wieczorek, 2005). However, there is little insight in TM literature into how to increase learning to facilitate the process of system change towards sustainability.

While this paper does not propose to evaluate TM as an approach to facilitate transformation of large scale infrastructural systems such as sanitation, TM does raise issues in regard to design's contribution to the transition to more sustainable socio-technical systems and in particular the process of social learning. Along with TM, sustainable design can also be understood in terms of deliberately planning socio-technical change, yet the social dimension of this change is significantly underplayed, certainly as it is characterised by the unpredictable 'dynamics of appropriation' of more fixed systems and artifacts (Shove, Watson, Hand, & Ingram, 2007: p. 8). As we have argued elsewhere, "the relational dynamics of change have not traditionally played a part in design biased towards the 'technological fix'"(Fam et al., 2009).

Design's traditional focus on product-oriented, market-driven, technical efficiency which produces finite 'solutions' to complex multi-faceted problems, has not proven sufficient in dealing with system change. Finite solutions tend to be based on obvious technical performance criteria such as an operational reduction in water requirements, but the design is more often than not disconnected from the context in which it has to operate. The evolutionary design of the flush toilet for example has significantly reduced water consumption, by lowering 'flush' volumes, from single flush (12 L), dual flush (6/3 L), low flush (4.5/3 L) to ultra-low flush (3/1.5 L) but sanitary systems challenged by the effects of climate change, rapid population growth and economic instability will require more than efficiency gains for a transition towards a more sustainable system of sanitation to occur (Fam et al., 2009). The hidden nature of sanitation systems in many western countries, means the majority of citizens are acutely unaware of the amount of water they 'consume' in their daily toilet use (Troy & Randolph, 2006), let alone the impacts of sewage on the environment and the significant cost of maintaining, operating and managing large scale and often ageing infrastructural systems. This lack of awareness is exacerbated by the design of the toilet which deliberately conceals its connection to a much broader socio-technical regime comprising of sewerage pipes, treatment plants, water supply, extensive capital infrastructure investment, rules and regulations dictating health standards on treatment and socio-cultural norms and perceptions, habitual practises, not to mention engineering practises, production processes, and skills which have become embedded in western society over the last century (Fam et al., 2009). In spite of the complex relationship of the artefact with the regime, the design of the flush toilet is a form of 'blackboxing' (Rip & Kemp, 1998) that disconnects the end-user from the water supply and waste production process.

If design is to influence shifts in the socio-technical regime towards more sustainable outcomes, then learning how alternative, more sustainable technologies are adopted and supported is an important part of the design process. If, as Rohracher (2006) argues, technological change is inherently social, then it would make sense for designers to consider how alternative forms of sanitation play out within a specific social context. Shove et al. (2007: p. 134) speculate that as the shapers and formers of artefacts, designers are "uniquely implicated in the transformation and persistence of social practise." Yet perhaps in part because of the largely sectored way in which design is taught and practised, this sphere of influence tends also to be under-recognised and underplayed.

2 Piloting urine diversion: research precedents

The rapidly growing awareness of the value of wastewater streams, in particular the value of phosphorus in urine, has led to a number of high profile international research institutes and water authorities piloting and trailing 'urine diversion systems' (UD). Pilot projects have been supported by institutions such as the German Technical Corporation (GTZ) (Blume, 2008), the

Dutch Foundation of Applied Water Research (STOWA) (Wilsenach & Loosdrecht, 2001), Swiss Institute of Aquatic Sciences and Technology (EAWAG) (Larsen et al., 2001), the European Union (Peter-Fröhlich, Pawlowski, Bonhomme, & Oldenburg, 2007) as well as Australian water authorities and government departments such as Yarra Valley Water (MacDonald & Narangala, 2008) and the QLD Department of Natural Resources and Water (Hood, 2008). Sweden in particular has the largest number of UD systems installed and the most extensive experience with implementing closed loop cycles of phosphorus recovery using UD systems.

In analysing the relative success of UD systems in Sweden it is important to note that many of the most enduring UD systems in Sweden today are those that have been collaboratively organised and/or managed by end-users (e.g. co-operative housing estates, eco-villages and private summer houses) (Fam & Mitchell, in press). Johansson, Kvarnstrom, and Richert-Stintzing (2009) characterise these actors as 'individual sanitation champions' willing to adopt first generation technology and deal with underperformance of the system as the technology aligns with ecological beliefs about sustainable living. Lessons learnt from these 'early adopters' piloting UD systems have contributed to knowledge development and feedback to manufacturers in developing iterative toilet models (Kvarnstrom et al., 2006). For these 'sanitation champions', the social drivers in adopting UD systems have not been in implementing UD as an individual technology but rather driven by a broader vision of what sustainable development meant within community living (Krantz, 2005; Norbeck, 1999).

In contrast to the success of many bottom-up initiatives where users played a central role, a number of UD pilot projects installed as top-down initiatives have struggled to gain socio-cultural acceptance, with several even dismantled over the last five years. A number of top-down pilot projects of UD systems installed in the public domain, for example in the context of public toilets in a museum, school, as well as residential housing, have revealed a distinct lack of end-user interaction in organising and managing the system and consequently a variable success rate compared to participatory bottom-up approaches in trialing UD. Repeatedly, these projects reveal a lack of consideration of the importance of social learning and therefore of facilitating social learning. The difficulty in introducing alternative sanitation systems in the public domain is the challenge of engaging end-users in new sanitation concepts, introducing alternative habits of practise and nurturing appropriate expectations of a novel technology.

The emergence and development of UD in Sweden pose some critical questions about the engagement of users in facilitating system change. The early bottom-up experimental projects in Sweden provide insight into how technological change might be facilitated through strategically managed design intervention. What has been obviously lacking in many of the failed UD projects

has been a direct engagement with users in the planning, design and implementation of UD technology (Fam & Mitchell, in press). Viewed through the lens of TM, the end-user can be understood as a fugitive 'stakeholder' whose input is critical in facilitating the introduction of radical innovations such as UD.

Lessons from the development of UD in Sweden have directly informed the design of the 'Funny Dunny' project and consequently the enormous importance the project has placed on engaging the end-user through strategies of design-facilitated social research. If sustainable design can be understood as the deliberate planning of socio-technical change, then this project offers an opportunity to test design's change agency on a modest, experimental scale.

3 The 'Funny Dunny' Project: research design

Instigated by a core team of researchers from the Institute for Sustainable Futures at UTS, the 'Funny Dunny' project has created a space for social learning within the university by collaborating with a broad range of interdependent stakeholders involved in the process of operationalising UD systems. The two-year pilot follows the life cycle of installation, urine collection, storage and reuse with the potential for the system to be recalibrated, up scaled or decommissioned at the end of the two-year period. By modelling complex institutional arrangements at the meso level of the sanitation system, the project seeks to identify the enabling conditions for "new infrastructural planning processes, sympathetic regulatory and legal frameworks; altered user practises; and re-cast cultural meanings in the water industry, agricultural and horticultural sectors and beyond." (Sankaran, Abeysuriya, Gray, & Kachenko, 2010). Reflecting this ambitious aim, participants include the local water utility, the Sydney Water Corporation; the NSW Nursery and Garden Industry Association; NSW Department of Health; Industry partners and Sydney City Council as well as UTS facilities management unit. University partners include Design and Agriculture faculties at UWS, Environmental Law at the University of NSW and sustainable sanitation researchers from Linkoping University in Sweden. At least a dozen UD toilets and waterless urinals from a select range of European and Australian manufacturers will be installed over the course of the project.

The Funny Dunny project utilises an action research methodology, which supports 'learning by doing' and collaboration in an iterative cycle of planning, acting, observing and reflecting (Kemmis & McTaggart, 1988). In keeping with the project's exploratory intent, the research design validates the discovery of constraining and enabling factors and records unanticipated problems as valuable information that could inform the transition to a more sustainable system of sanitation (Figure 1).

The integration of stakeholders across disciplines is central to creating a well functioning system design (Charnley, Lemon, & Evans, 2010). Five strands of activity represent multiple aspects of the research and enable the learning of

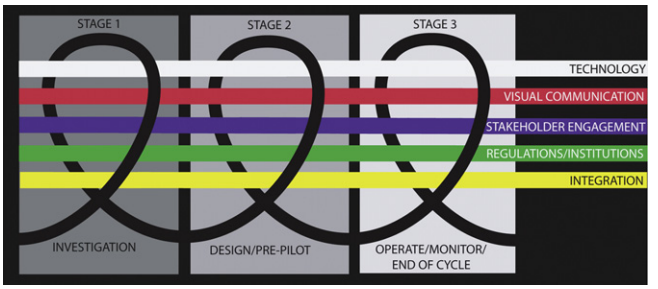

Figure 1 Action research loops: mapping the research design of the pilot

participants to be articulated and reflected upon. The technology strand is engaged in issues associated with hardware and retrofit, technical performance and implementing the agricultural trials; the visual communication design strand involves the development of tools to facilitate user engagement; the stakeholder engagement strand looks at the collection of social data; and the regulations/institutions strand deals with landscape issues that might enable or constrain the diffusion of the system beyond the confines of the pilot project. Finally, the integration strand takes a whole system approach and functions as a steering mechanism, overseeing the project, identifying impediments in the process and tapping into areas of crossover between research strands. This arrangement forms a new transdisciplinary social network, which has directive agency in shaping the course of action and can observe at close range how the intersectorial implications of the system unfold. This is facilitated by a multipurpose project website which is organised into strands and enables the geographically dispersed social network to function as a virtual 'community of practise' (Wenger, 2002).

The three phases of the project involve investigation, design and operation. At the time of writing this paper we have finalised the design phase and are commencing the operational phase of the pilot. While the research project spans regulatory, technological and social engagement issues related to UD, the design team was charged with addressing how an innovative and socio-culturally challenging system of sanitation is received, handled and experienced by its users. The following sections detail the contributions of the visual communication strand, which was particularly active in the investigation and design phases. It shows how a richly informative feedback loop was created between designers, project stakeholders and end-users during pre-pilot testing in the design phase.

4 *The role of visual communication design in supporting system change*

The visual communication design strand (comprising the authors of this paper), is closely allied with the stakeholder engagement strand. During the investigation phase, the strand tasked itself with creating highly visible and accessible tools that would help to configure and prefigure what system change

might look and feel like for the everyday user. While other disciplines of design have significant parts to play in the retrofit and domestication of technology, the project hypothesised that visual communication design has a critical role to play in introducing a 'greenfield' issue in the public imagination; preparing the ground for a taboo subject to be broached, and for the highly personal and deeply embedded practises of toilet use to enter 'discursive consciousness' (Hobson, 2003). Designers needed to take account of a richly complex problem space in which standards of comfort, cleanliness and convenience (Shove, 2003) were disturbed, and at some levels directly challenged.

There was a range of socio-cultural barriers for the new system to overcome, such as an aversion to the idea of nutrient recovery from sewage (particularly for use in food production). There were also a number of new habits of practise that needed to be encouraged within the private space of the toilet, such as the need for men to sit down to urinate and for users to consciously and carefully modify their behaviour in the placement (and amount) of toilet paper to reduce potential blockages. There were also implications for other users, such as cleaners, plumbers and maintenance staff. Through the use of appropriate visual communication tools, we were seeking to sensitise end-users to a new environmental story that would transform the meaning of embedded, everyday routines (Figure 2).

Part of the impetus for involving visual communicators in this project was the prevalence of poor visual tools identified in previous pilots, such as inaccessible user manuals and inadequate signage. There was a strong need for improved communication tools to not only inform all system participants about the 'how and why' of the system, but also to gather social research on perceived challenges, insights and reflections by end-users during the design and operational phases of the project.

Figure 2 Wostman urine diverting toilet used during the pre-pilot trial. Urine is diverted into the front section of the partitioned bowl

A key role of the stakeholder engagement strand was to develop relevant questions to help shape the appropriate design tools with specific users and practises. A sample of these questions are indicated below:

How do we engage the university community and the broader public in a conversation about 'the story of (p)hosphorus'?
How do we introduce the 'Funny Dunny' project and prime the university community for its installation?
How do we encourage the community to participate in trialing the 'funny dunnies'?
How do we inform users of the new practises the UD toilets require?
How do we encourage careful use and discourage vandalism?
How do we engage with non-English speaking users or those who need different styles of communication?
How can we document patterns and preferences in toilet use?
How do we gather feedback and involve users in further developments?
How do we engage with cleaners/maintenance staff to support changed practises?
How do we bring clarity to unfamiliar technical problem situations for technical staff?
How do we engage with facilities management staff to explain the new system and implications for retrofit?
How might people respond as citizens rather than consumers regarding the reuse of their waste?

These questions helped to articulate the spread and prioritisation of visual communication strategies and deliverables across the three stages of the project, with a view to project dissemination and upscaling. These strategies are detailed in the following diagram (Figure 3).

5 *Design for social learning*

One of the primary motivations for this project was to understand the importance of social learning in the introduction of a new technological system. While there are differences in understanding regarding the concept and theoretical basis of social learning (Reed et al., 2010), in this project we defined it not only as a demonstrated change in understanding by involved individuals, but also a change beyond individuals to extended communities of practise through social interaction. The reflective research design encouraged the evolution and documentation of social learning throughout the project. This process occurred primarily by way of regular meetings, at which learning across the research strands was shared and new questions developed. In addition, the core project team actively encouraged a culture of collaborative writing, within but also between strands. The value of this last measure to support social learning was strongly indicated by in-depth, semi-structured interviews with project partners at the close of the design phase, which were explicitly

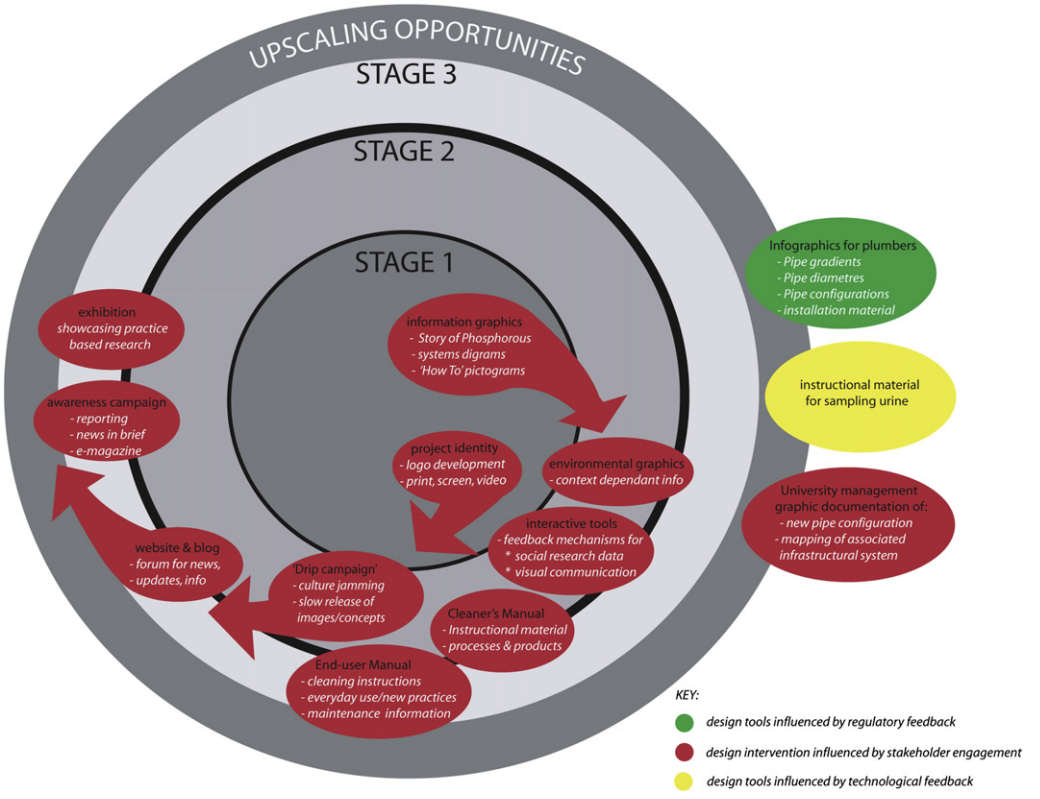

Figure 3 Visual communication strategies mapped across the three stages of the pilot

framed to capture reflections on learning. The social learning of end-users was captured via designed feedback mechanisms that elicited immediate responses to the new system *in situ*. These are discussed below.

The development and implementation of visual prototypes and engagement tools in the very early stages helped researchers to observe the emergence of social learning as end-users documented modifications to their practises and provided a record of their conversations during the pre-pilot. Students across two design schools participated in the generation of initial visual concepts through the investigation phase of the project.[2] In order to participate effectively, these students needed to understand the project in some depth. The design brief was seen as an important mechanism to facilitate this understanding, enabling students to jump into a complex and unfamiliar problem space and providing them with ways to move forward within it. The design brief has been discussed in the sustainability literature as an important means of introducing sustainability options to clients and a mechanism of negotiation that can shift the balance of power between clients and designers (Fry, 2009). In this project, the brief was an important mechanism to facilitate social learning, functioning both as a vehicle to introduce new ideas to student

designers and as a way to consolidate the visual communication requirements of the system for the 'Funny Dunny' team, as detailed in the above diagram.

The design briefs asked students to consider how to 'give voice' to the pilot; to invite end-user participation; to explain the closed loop system of the pilot; the phosphorus cycle and the current situation of depletion; and to animate debate about the issue of waste as a resource. Initial discomfort and embarrassment in confronting the subject matter of toileting – a taboo issue for several – dissipated once the space between subject expert briefings about the proposed trial and their own research had been closed. Bridging that gap was crucial. Framed by key investigators as research of serious and urgent intent, students quickly understood the project's importance as well as design's transformative potential within it. As such, their viewpoints underwent dramatic transition: initially viewed through the lens of visual communication as merely persuasion or a transaction for personal gain ('Who owns my pee and why should someone else make money from it?'), this limiting rubric was shed in favour of inclusiveness and community building.

5.1 *Two examples of social learning*

Two examples of social learning are unpacked here: the first, a deceptively modest example of a shift in philosophy can be seen in the development and use of the simple phrase, 'Thank you for your pee'. Originally, elaborate concepts to tangibly 'remunerate' participants for donating urine were devised; no other construct could be imagined other than that of reward. As deeper research was undertaken, including informal talks with other investigators, a noticeable shift in thinking occurred: 'reward' was deemed not only unnecessary but also undesirable and selfish. Why couldn't and why wouldn't people 'donate' their urine in both service and support to a purpose larger than themselves? 'Thank you for your pee' was coined from a collective and unstructured class discussion, a phrase neither ingratiating nor limp, taking form in sheets of toilet paper (Figure 4) and heat sensitive stickers adhered to urinals (Figure 5). The simplicity and honesty of the message without a bargaining mentality attached have resonated with those interacting with it.

The second example concerns the social learning of end-users evidenced via the installation of visual prototypes in situ. The pre-pilot installation captured a sample of approximately fifty staff across two departments as well as visitors to these departments, who had the choice of using either conventional or UD toilets. Students developed a 'graffiti board' for the washroom, which elicited immediate end-user feedback on the experience of using the UD toilets (Figure 6). The writing surface was replaced weekly for a period of twenty-six weeks. The simple design – reminiscent of artist Ji Lee's iconic participatory speech bubble project that first colonised public urban spaces in New York City in 2002 – enabled a space for 'conversational learning' (Kolb, Baker & Jensen, 2002) to occur, in the form of written commentary but also

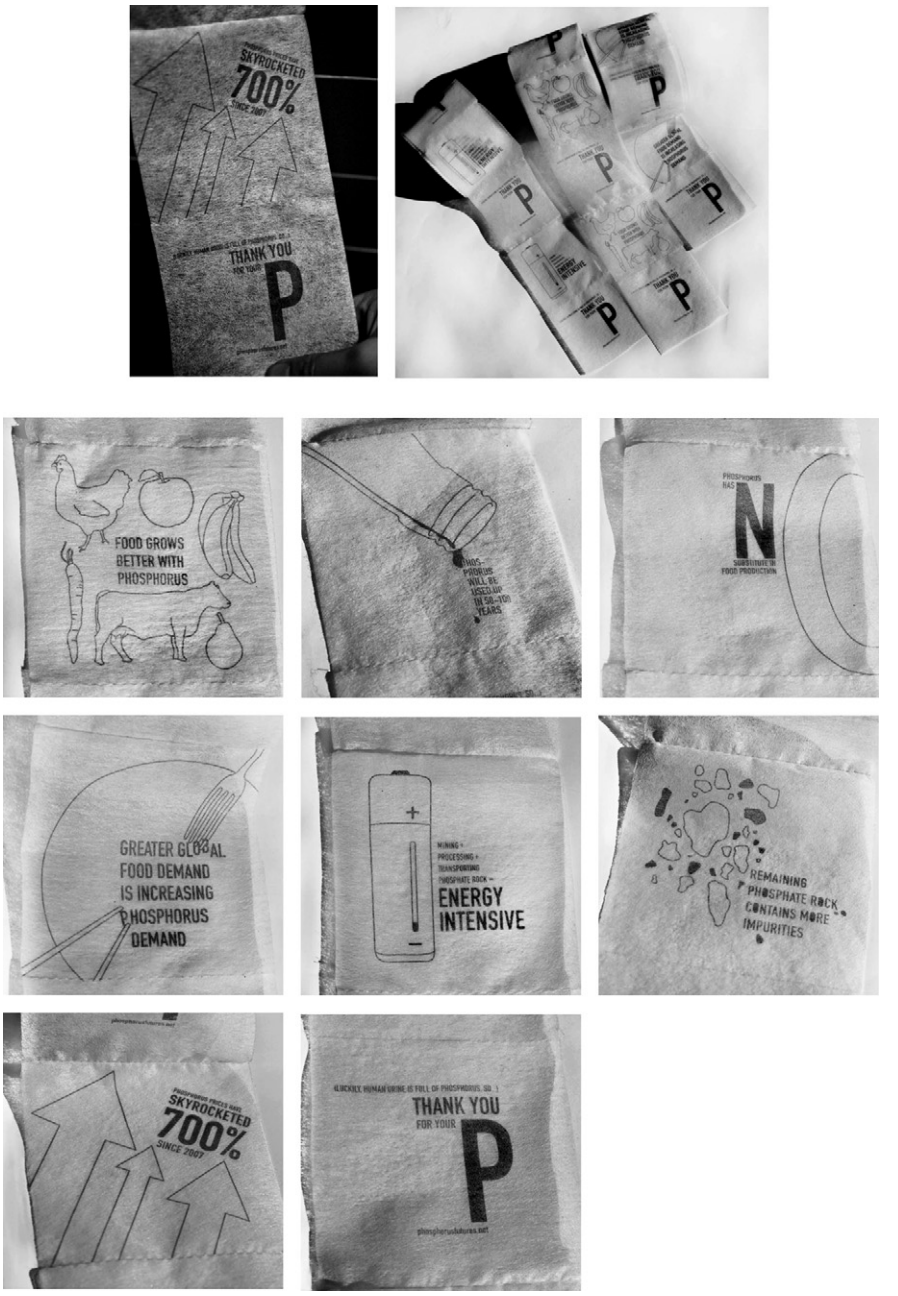

Figure 4 Graphics for toilet paper range (based on '8 reasons why we need to rethink the management of phosphorus in the global food system', Cordell et al., 2009). 'Thank you for your pee' appears on every second sheet of each roll. Designer: Rebecca Lam, UTS

animated verbal exchanges amongst end-users. The graffiti board provided the research team with access to a continuous stream of rich social data, and the ability to track evidence of social learning over time. Data was collated from daily commentary and emerging themes identified within the broad theoretical

Figure 5 'Thank you for your pee' heat sensitive sticker, a still of 'closing the loop' cycle, and 'in situ' as motion sensor in front of urinal. Designer: Jethro Lawrence, UTS

framework of social learning, of which communication, interaction and participation are key determinants (Blackmore, 2010; Wenger, 2002). Recorded reflections on changing practise as well as personal experiments and ancillary comments from other end-users provided evidence of social learning, which was correlated to observations on the physical state of the toilets at the end of each day.

Commentary ranged from the relatively superficial (*love the cool/funky posters!*) to incisive comments on the design of visual tools, through to detailed and valuable feedback on usability, with at times, quite elaborate sketches. The graffiti board captured a frank, practical approach to the use of the new toilets with participants disclosing experiences and idiosyncratic problem solving, and noting how their conventional habits of practice were changing with recurrent visits. Both the reduced incidence of blockages and the declining number of comments related to blockages for example, provided tangible evidence of the changing habits of users. Regarding the postural change required of male users of the UD toilet, one user wrote:

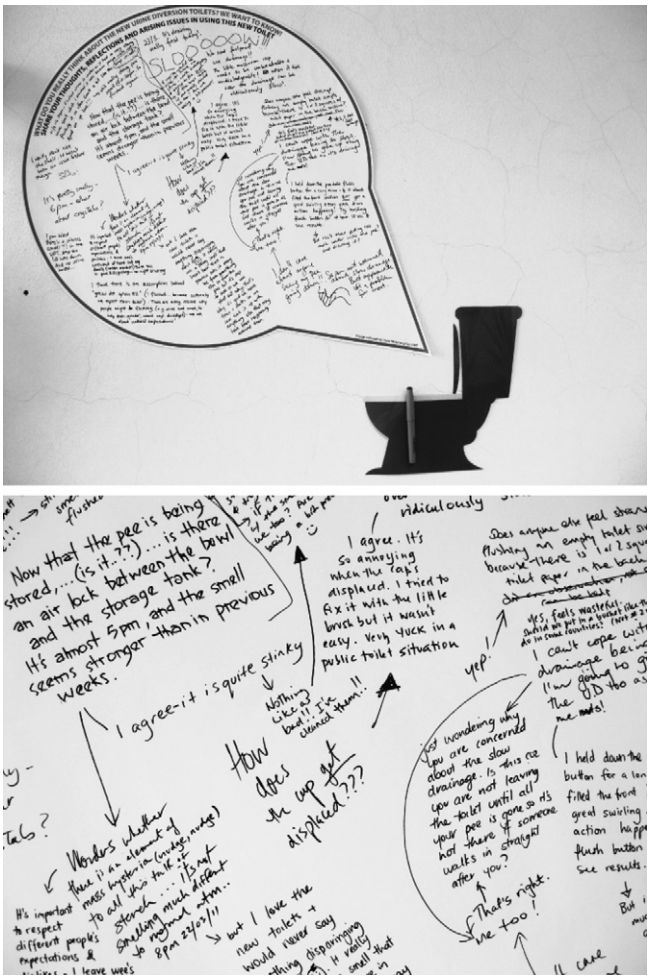

Figure 6 Graffiti board in situ and detail. Designer: Yana Mokmargana, UWS

> *I got my hand wet removing toilet paper from the pee hole – need target precision with both pee and toilet paper*

Another participant commented that involvement in the project was *a really good awareness-raising tool. I never put any thought into how many squares of loo paper I was using – now I think about it to see if I really need it*.

Participants considered how much water was being used to flush the toilet using different approaches:

> *The half flush goes for ages if you keep your finger down – it seems almost like a full flush. If you lift your finger early it stops flushing earlier! This may save even more water*.

We noted a significant change from the first weeks of installation where commentary focused on the practical functionality of the system to later commentary where participants wanted further information on system design. A number of participants noted a desire for further up-to-date information on the project and the development of the system as a whole, even suggesting ways in which relevant information could be diffused to expectant end-users.

> *Maybe provide a link where we can access more info…and updates. Is the phosphorus being collected yet? Where is it going?*

Others expressed a desire for aggregated information so end-users could get a sense of the contribution they were making:

> *…like 'last week's users of this toilet diverted x grams of valuable phosphorus for use in agriculture'.*

The questions and ideas emerging from the graffiti board installation have prompted the researchers to reconsider how information is provided to end-users and how to tailor feedback mechanisms to capture the dynamics of social learning throughout the more extensive operational phase. It is anticipated that this feedback will be of great interest to the manufacturers of new sanitation systems as the operational phase of the project evolves.

5.2 Discussion

These two examples demonstrate that the involvement of visual communication design as an active component of the research has helped to facilitate not only the collection of social data, but also its idiosyncratic richness. Visual concepts were adjudicated by research investigators across the research strands, thereby generating fruitful discussion about the value and potential contribution of visual communications design to furthering the key aims of the project, as presented in the visual strategies diagram. The feedback loop created between stakeholders and researchers, facilitated by visual tools, has helped to sharpen researchers' understanding of how a novel technological system becomes socialised. Equally, design students' involvement in introducing closed loop cycles of nutrient recovery from sewage to the target audiences, has had a transformative effect on their own understanding as they negotiated the brief.

The primary purpose of the social research within the project to date has been to determine perceptions of the new toilet; issues arising in use and what could be done via action research to facilitate the smooth transition to new practises by users (staff, students and visitors), cleaners and facility management. Critical feedback and expertise has also been provided by technical maintenance, plumbing and cleaning staff who have not only documented issues related to the installation and maintenance of the pre-pilot system, but have also provided invaluable feedback on social practises in public toilet use on campus. This subsequently influenced the location of the pilot and deepened design students' understandings

of the socio-cultural issues involved in introducing alternative systems of sanitation in the contextual setting of an urban educational institution.

The benefit to design students in engaging with the evolution of stakeholder feedback over a prolonged period of time was that they became aware of the evolving needs of various users in adopting new technology. By the end of the project it is anticipated not only that the pre-pilot will have contributed to the development of sophisticated and context specific visual tools, but also tested an approach that reframes visual communication design as a facilitator of system innovation, that can be shared with other researchers and designers. We see the trial as teasing out a fledgling model for visual communication design education as both a critical and social discipline. Its placement at the 'fuzzy front end' of the project promises to reveal fuller disciplinary capacities, demanding an exploratory stance where solutions are not prematurely sought. Positioned thus, design's traditional remit of solving problems identified by others is jettisoned in favour of seeking issues of concern through which to frame ongoing, provisional work within transdisciplinary projects. Ultimately, we will have graduating students who have participated in 'discovery learning' (Warburton, 2003) with a practical understanding not only of design's social agency but a sense of themselves as agents to support socio-technical change.

The inclusion of visual communication design in this pilot project embeds several lessons about sustainable design: It positions design at the 'fuzzy front end' of system change where boundaries are set and decisions are made, leading students to frame interventions from a proactive stance rather than from an historically reactive position; it stresses the importance of finding leverage points (Meadows, 1999) for appropriate intervention in an existing system; and it mobilises design's historical capacity to anticipate future drivers and to help indicate what system change might look and feel like ahead of time, thereby intentionally prefiguring cultural change. It also emphasises the importance of collaboration over individual action. In fact the transdisciplinary action research model is closely allied to the mutual learning and multi-stakeholder environment advocated by emerging practises of 'co-design' (Fuad-Luke, 2007). This is supported by the fact that student design teams were dependent on expert knowledge provided by 'Funny Dunny' team and collegial collaboration between the university partners. As they consulted on the progress of visual prototypes, the transdisciplinary research team was also exposed to processes of conceptual evolution particular to design that had not readily been available to them before.

The ambitious scope but modest scale of the project has enabled the intense generation of context specific issues for designers to act and reflect upon. The visual communication design strand has developed a greater understanding of the facilitation role as a legitimate design activity, the complex issues and processes at play during problem finding and solving (Dorst & Cross,

2001), and of the value of the brief as a mechanism to promote social learning between designers and their clients. It is anticipated that this learning will continue as the project progresses into its operational phase.

6 *Concluding remarks*

The university provides an ideal setting for niche experiments of this kind, as is has a mandate to nurture 'the seeds of change' (Geels, 2002). The university has been described as a microcosm of society (Cortese, 2003) and a 'lab' and 'window' to design and promote sustainable innovations (Penin & Vezzoli, 2004; Vezzoli, Ceschin, & Kemp, 2008). It can be seen as a hypothetical space in the culture at large, in which the risk of innovation for industry or community stakeholders can be absorbed as research enterprise (Allen, Lopes, & Andrews, 2009). Universities have a responsibility to generate new knowledge that fosters collaborative engagement with real-world issues (Fullan & Scott, 2009). Internationally, the university has been charged with addressing climate change issues and equipping its staff and graduates with sustainability literacy (ULSF, 1990; UNESCO, 2005). The 'Funny Dunny' project responds to this call by engaging designers to facilitate social learning in the transition to a more sustainable system of sanitation. We present the UD pilot less as an innovation for a future world than as the most reasonable response to the landscape issues currently confronting us. While the project anticipates a more sustainable sanitation future by closing the phosphorus loop in a local context, it is very much engaged with the antecedent world of infrastructures, institutions, social taboos, practises and perceptions across all levels of the existing system. It is in this space between what already exists and what is new, that the possibility of change is negotiated. It is anticipated that the pilot will act as an exemplary case study of how transition-based sustainability research might proceed, and the integral contribution of design in facilitating socio-technical change.

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Notes

1. 'Dunny' is Australian slang for 'toilet'.
2. 'Information Design' is an elective within 'Design Projects', a core 3rd year subject at the University of Technology in Sydney. It is the vehicle through which students are formally

introduced to 'live' projects in their 4-year degree. 'Professional Brief' is a core 4th year subject at the University of Western Sydney, in which students conduct 'live' client-driven projects in 'The Rabbit Hole', an in-house design studio.

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