Transitioning to sustainable sanitation through cross disciplinary, practice-based research: an on-campus pilot of urine diversion at UTS

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1. INTRODUCTION

Waterborne sanitation using flushing toilets and sewer networks has been recognised as "the most important medical milestone" for its transformational impact on urban public health since the 19th century (Ferriman 2007). While this model of urban sanitation has become the accepted norm for the industrialised world, its cost and resource-intensive nature is increasingly recognised as unsustainable. Several alternative models offering improved sustainability through greater material efficiency have emerged (West 2003). One of these is urine diversion (UD), the topic of this paper.

Diverting urine at source – the toilet – makes good sense for several reasons. Keeping urine out of the sewage stream eliminates the most significant source of nutrients in wastewater[†], thereby reducing the costs of wastewater treatment to remove these substances (Larsen et al. 2001; Maurer et al. 2003) that otherwise pollute aquatic environments.

The potential to reuse the nutrients in agriculture is particularly promising in a context where known reserves of phosphorus rock are depleting at rates that could lead to serious shortages by the end of this century (Cordell et al. 2009). Phosphorus (P) is required by all living cells and has no substitute for agricultural production. Urban cities may potentially act as 'mines' for a concentrated renewable supply of phosphorous.

Capturing, valuing, and reusing urine reflects a radical shift from current embedded socio-technical systems of sewage management (Mitchell et al. forthcoming). To effect such a shift requires mutually reinforcing institutional and sociocultural transformations that support the introduction of new technologies: new infrastructure planning approaches, regulations, user practices, markets and business models, and cultural meanings (Geels 2005) in the water industry, the agricultural sector, and beyond – especially as human waste is an 'unspeakable' taboo in many cultures. To understand and manage these multi-dimensional factors requires transdisciplinary knowledge, know-how and partnership.

2. PILOTING URINE DIVERSION SYSTEMS ON-CAMPUS

A pilot research project of UD hardware retrofitted in a block of toilets on the campus of the University of Technology Sydney (UTS) to enable urine capture and reuse, seeks to explore the various interdependent factors that determine successful uptake of UD as a socio-technical innovation in wastewater management. The project is enabled by a UTS Challenge Grant for fostering cross-disciplinary research with innovative and practical outcomes, with the current round funding projects aligned with the

[†] Urine typically contributes of the order of 80%, 50% and 90 % of the nitrogen, phosphorus and potassium in wastewater respectively (Larsen et al. 2001).

University's Strategic Plan (UTS 2009) including the City Campus Masterplan that is committed to holistic sustainability goals.

The research team is led by academics from UTS and includes UNSW and UWS academics in an inter-university collaboration that brings research strengths in Sustainable Futures, Engineering, Project Management, Visual Communication, Law and Agriculture. Key industry and government stakeholders are also strategically involved, including Sydney Water Corporation, toilet products manufacturer Caroma Dorf, the industry group Nursery and Garden Industry Australia, NSW Department of Health and the local government authority City of Sydney. They bring a range of disciplinary and practice-based expertise needed to explore multi-level change, as well as significant financial and in-kind contributions. The University's Facilities Management Unit is another key partner providing practical funding and personnel support for the necessary capital works.

The industry/government/university collaboration intentionally creates space for industry relevant practice-based learning for early career researchers and for students through short term (undergraduate) and long term (postgraduate) involvement. In this paper we discuss the latter aspects of this research – the sustainability curriculum and engagement of students in a practice-based project.

3. INTEGRATION OF RESEARCH APPROACH AND CURRICULUM

The 2-year research program takes an action research (AR) approach with three cycles: investigation (first half of 2010); design and commissioning (second half of 2010), and operation and evaluation (2011). The key dimensions of the research are addressed by four distinct 'disciplinary' research strands while a fifth research strand is focussed on integrating the other strands with a whole of systems perspective (Figure 1). As the purpose of action research is to yield change (action) and understanding (research) at the same time, the integration strand acts to ensure critical reflection and understanding throughout the process is appropriately acted upon in each research strand by overseeing the development of the project from multiple perspectives.

The *technology* strand includes all aspects of the physical system - hardware, installation, operation and maintenance, urine collection system, and trials in agricultural reuse. The first action research cycle investigated selection criteria and evaluation options for the specific location of the pilot as well as identifying the most appropriate hardware (toilets/urinals, plumbing) to be installed. Reflections from this cycle have determined how we are approaching the current second stage of designing and contracting the pilot project. The *stakeholder engagement* strand will monitor attitudes of stakeholders - including staff, students, visitors and maintenance staff- and how these might need to shift. The first cycle involved not only preliminary surveys and social research but, importantly, developing working relationships with a broad range of influential stakeholders including cleaning staff, contracted plumbers and end-users of the toilets. The insights from the first stage of stakeholders engagement has influenced the direction for the social research as well as decisions about the hardware and location for the pilot. Since effective communication plays a critical role, a separate *visual communication* strand is focussed on developing a range of tools to inform, educate and engage stakeholders. A series of design briefs for 3rd year visual communication students at UWS and UTS have been developed as part of an industry partnership program. Feedback from both social research and stakeholder engagement will further inform students working on this project and the resulting design will be more closely

related to research findings.The *regulations/institutions* strand is focused on understanding the regulatory and institutional context and their role as enablers or barriers to innovative sustainable sanitation. Identifying the legislation triggered by urine diversion and storage, and what impacts the legislation has for moving beyond a 'demonstration' in Australia has been the focus of the first research cycle.

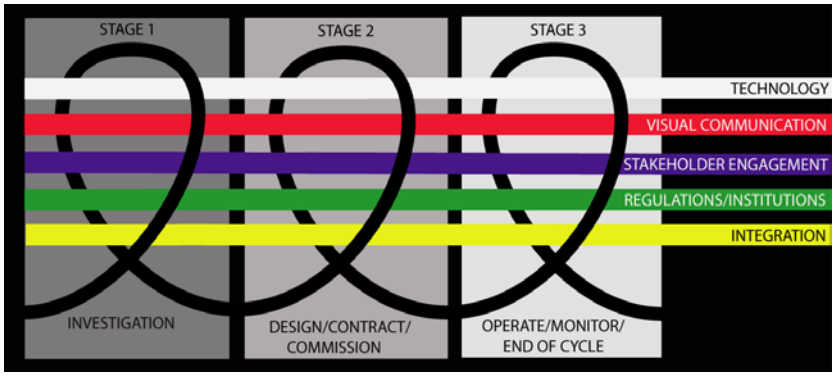

Figure 1: Action Research approach with research strands addressing key dimensions

Research team members belong to one or more research strands based on their strengths and interests. UTS early career researchers have been given an opportunity to develop research leadership capacity within the strands, supported and mentored by senior researchers.

The engagement of students forms an integral part of the project. A PhD candidate in Sustainable Futures has a project management role in this project that will allow her to gather research data for her studies. Undergraduate students from Engineering and Visual Communication Design have commenced semester-long projects, with Agriculture and Law to follow shortly.

3.1 Integration of Doctoral research curriculum

The author Fam is a PhD candidate at the Institute for Sustainable Futures (ISF) examining the barriers and opportunities of resource recovery from urine diversion systems and the potential for system innovation in wastewater management. With the awareness that sustainability is a complex field requiring a transdisciplinary approach (Costanza et al. 1996) and multi-stakeholder engagement, postgraduate researchers at ISF tend to work across multiple disciplines with the aim of creating tangible outcomes toward sustainable futures. Fam's research and theoretical understanding of transition management (Kemp, Loorbach & Rotmans 2007) from her doctoral investigation has been practically applied in designing the pilot project.

Transition Management (TM) offers strategies to consider broader possibilities for innovation beyond incremental improvements to dominant existing designs which is the usual approach to sustainable improvements of systems such as wastewater management. TM is a deliberate attempt to bring about structural change in socio-technical regimes (Kemp et al, 2007) with an emphasis on involving key stakeholders '…to define multiple visions of the future…and realise important collectively defined goals' (Meadowcroft 2009, p. 325). The actors and activities strategically chosen to collaborate on this project both support and positively contribute to the introduction of a radically different sanitation system across multiple dimensions of the sanitation system. The process of developing 'collectively defined goals' across over twenty

university/ industry/ government collaborators has meant developing interactive processes where involved actors come together, develop shared problem definitions and share differing disciplinary perspectives while developing practical activities.

The innovative nature of this project does not only relate to the technological system being installed but also the practical implementation of an emerging theory of transition management which to date has had relatively few applications internationally (Elzen, Geels & Green 2004) and no experimental research conducted within Australia. The experience gained from both doctoral research and investigation by undergraduate students on UD systems has contributed to the direction taken in installing and managing the project. In particular Fam's investigation of the barriers and opportunities of installing UD systems in Sweden has provided critical input into the challenges of implementing radical innovation (Fam et al, 2010).

3.2 Integration of Engineering curriculum at UTS:

The Faculty of Engineering and IT is committed to developing and delivering a curriculum that includes sustainability and practice-based education. As stated in the faculty's strategic plan (2010-2013) it is expected to increase visibility and priority to practice-oriented programs (FEIT, 2010).

As one of the main aims of this project was to develop collaborative cross-disciplinary research, undergraduate engineering students are involved in contributing towards technology related investigative inputs. This in turn fulfils particular aims of the engineering course at UTS such as Bachelor of Engineering and Diploma in Engineering Practice (BE DipEngPrac). The undergraduate program is fully accredited by Engineers Australia, a professional engineering body that 'sees itself as part of a global community of professional engineering associations that reflect and contribute to world best standards in engineering education and practice' (Engineers Australia 2003).

Engineers Australia expects engineering graduates to develop skills according to two stages of competencies: *Professional Engineer* and *Engineering Practitioner*. The UTS engineering program as accredited by Engineers Australia allows graduates to have fulfilled both these competency standards.

The students involved in this project come from a cohort of Civil or Civil and Environmental Engineering and will be involved on a short-term basis (either 6 or 12 months). Within each of these major subjects students are given opportunities to develop skills through field of practice subjects, core engineering subjects, a capstone project and through engineering practice program.

Involvement of students in this current transdisciplinary project not only provides opportunities for students to fulfil *Professional Engineer* competencies, but they also help to contribute towards *Engineering Practitioners* competencies such as those required by Engineering Practice (C1), Engineering Planning and Design (C2) and Self Management in the Engineering Workplace (C3) as identified in the following section. In the current project, students have an opportunity to interact with professionals from other fields and research strands to seek a range of information to strengthen the engineering focus. Cross disciplinary input challenges students to understand alternative viewpoints and deliver solutions through a multi-disciplined, inter-cultural approach.

Students are required to prepare concept proposals based on review of the latest technology available as well as to show commitment throughout the project by managing themselves, their time and other resources. They are also required to demonstrate that they can work effectively with other professionals and manage information especially that related to legislation, statutory requirements and standards.

The current project commenced February 2010, and so far one BE DipEngPrac (Civil) student has been involved in the 'Technology' strand of the project. Participation has involved a 'capstone project' which is a segment of the degree; however through his involvement, the student also was able to demonstrate skills that contributed to Engineering Practitioners competencies as stated by Engineers Australia. It is expected that this project will support a number of UTS Engineering students through practice-based research contributing to developing and utilising their engineering skills in a practical way.

3.3 Integration of Visual Communication curricula at UTS and UWS

Visual communication (VC) is positioned as a core constituent in this project. The innovative approach of incorporating VC at the commencement of the pilot rather than adopting VC at the completion of the project relocates design from its traditional back-end problem-solving mode to a front-end strategic space where unframed problems need to be identified and clarified.

The motivation for engaging visual communication at such an early stage of the project is that VC is best placed to facilitate a negotiation between existing and desired future practices, to urge a rethinking of everyday habits. This approach replicates current opinion in design education where 'designing' is considered more than the development of a finite artifact but has the potential to be perceived as a strategic activity to facilitate change toward sustainability in designing 'the conditions of use' (Drucker & McVarish, 2009). This approach therefore moves the discipline to a more critical and reflexive space, engaging deeply with emergent societal issues as well as developing insights into the nature of the transdisciplinary relationship.

Two design schools in Sydney – UTS and UWS – are contributing visual communication expertise to the project. In the initial 'Investigation' loop (February 2010- July 2010), both programs were supported with detailed briefings and ongoing input from project experts. Students were operating within the framework of more open-ended, exploratory spaces in their respective programs through which to engage with contemporary issues: at UTS this was through Information Design; at UWS, through the Professional Brief.

Students identified key issues to 'give voice' to the project: to raise awareness and engage the university community and wider public in a conversation about the story of (P)hosporous; to invite participation in the pilot; to explain the P cycle and the current situation of depletion; to animate ongoing debate and decision-making about waste as a resource. As a starting point to the above they were then asked to consider the following through which to frame their own questions, research and visual response, for example: how might we design an information system that encourages people to make informed decisions about waste as well as ask informed questions of the project and of their community leaders; how might people respond as citizens rather than consumers regarding the re-use and ownership of their waste; 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 bring clarity to unfamiliar technical problem situations for technical staff.

In this first phase, outputs can be found in two broadly defined areas: designing *systems* and designing *understanding*. The former has found expression in an all-encompassing identity for the project, providing structure for the latter. Students have designed 'branding' solutions via puns or the vernacular (Phos4us, Taking the P) to the more metaphoric (Harvest). It is envisaged that a designed system would provide ongoing visual recognition triggers for the university community, exemplified through the rollout of 2, 3 and 4D materials, for example, wayfinding to the trial site, environmental graphics within the toilet areas, and a web presence.

Visual communication strategies in the next phase will see the refinement of the above, informed through the lens of further social research and user testing. These are essentially 'front-of-house' issues, the public face of the urine diversion trial. Revealed in the first phase were 'back-of-house' issues that needed to be addressed; these ranged from articulating cleaning procedures to designing diagrams/ explaining retrofitting implications for technical staff. Several 'back-' and 'front-of-house' materials are capable of up scaling beyond the trial requiring these be designed for seamless adaptation.

3.4 Integrating student-based projects in Agriculture and Law

The second phase of the project will bring opportunities for involvement of students in Agriculture at UWS and Law at UNSW, under the supervision of relevant collaborators at each institution.

Agricultural pot trials can commence once the pilot is operational and urine samples can be collected – starting in 2011. Nursery Garden and Industry Australia will collaborate with the UWS partner to support and provide co-supervision for honours-level student projects. The opportunity for students to engage with industry partners will be highly beneficial in building capacity for industry-relevant practice and innovation.

At UNSW students will have various degrees of involvement in answering the research questions in the *regulations/institutions* strand, including understanding the existing legal and regulatory landscape relevant to installing and maintaining UD systems, as well as more fundamental questions relating to property rights in urine (Gray 2008), and possible implications for the incumbent water/wastewater service provider. In addition to defining the existing regulatory space for the introduction of UD, they will examine potential changes in regulation that might support nutrient recovery and reuse in the future. Law students will be investigating the institutional structures, whether they be law, policies and guidelines that would need to change to facilitate effective urine diversion and reuse in Sydney.

4. CONCLUSION

The UD project at UTS aims to approach sustainability research and education from a practice-based transdisciplinary perspective where researchers and students from design, law, engineering, agriculture and sociology provide feedback across disciplines throughout the duration of the project. The university setting, with inherent commitment to systematic and rigorous research inquiry, is particularly suited for creating a 'safe' exploratory space for research of this nature. This research grounded in

an on-campus pilot facility provides unique opportunities to connect campus and curriculum in ways that allows students to build practical skills while fulfilling course requirements.

The pilot research project described here is a starting point to open up long term research and practice in transitioning to more sustainable sanitation systems. Such transitions require processes at multiple dimensions and levels to link and reinforce each other (Geels 2005). The broad university/industry/government cross collaboration is key to enabling such processes as well as facilitating subsequent diffusion and growth into diverse practice-based networks.

The research will create a unique opportunity for application of UD within the UTS City Campus Masterplan (UTS 2009) as it plans new buildings, significant refurbishments and innovative extensions to existing facilities, and could accommodate UD systems within its long term planning horizons.

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