The Transdisciplinary Living Lab Model (TDLL)

Dr Dena Fam Ph.D.
Institute for Sustainable Futures, University of Technology Sydney
235 Jones St, Ultimo, Sydney, 2007, Australia
Email: Dena.Fam@uts.edu.au

Dr Abby Mellick Lopes Ph.D.
Institute for Culture and Society, Western Sydney University
Building EM, Parramatta, NSW, Australia, 2751
Email: A.MellickLopes@westernsydney.edu.au

Katie Ross MA.
Institute for Sustainable Futures, University of Technology Sydney
235 Jones St, Ultimo, Sydney, Australia
Email: Katie.Ross@uts.edu.au

Dr Alexandra Crosby Ph.D.
Faculty of Design, Architecture & Building, University of Technology Sydney
235 Jones St, Ultimo, Sydney, 2007, Australia
Email: Alexandra.Crosby@uts.edu.au

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Abstract

A Transdisciplinary Living Lab Model (TDLL) was developed in collaboration with two Australian Universities: the University of Technology Sydney and Western Sydney University. This TDLL model takes a transdisciplinary approach to learning while utilizing the university campus as a living laboratory. This chapter presents the processes used to create, and discusses the benefits of creating, a conducive environment for transdisciplinary learning on-campus in a project-based living lab.

The Transdisciplinary Living Lab case studies introduced in this chapter focused on food waste. In these TDLL experiences, a diverse range of students from many disciplines were mentored by course facilitators with expertise in transdisciplinary research and practice, to learn how to contribute their own disciplinary knowledge and expertise in transdisciplinary teams seeking to reduce food waste on campus. In addition, as a deliberate attempt to guide students to consider how local food practices impact on global systems, university system experts incorporated the Sustainable Development Goals (SDGs) into the TDLL activities. The students were also supported to communicate these insights in public, open and iterative platforms. In sum, the TDLL model was designed to facilitate students to:

(1) reflect critically on their embedded views of, roles in and impact on campus systems;
(2) develop skills in collaborative research to identify, bound, reflect and intervene to improve campus systems;
(3) justify the scientific and societal benefits of transdisciplinary outcomes for sustainable development.

The TDLL is systemically transformative in that it integrates undergraduate curriculum, university operations and research, priming the university to practically meet the SDGs. Utilizing campus infrastructure as a living environment for applied, collaborative learning not only advances sustainability on campus but prepares students with the skills, knowledge and enthusiasm to be active, engaged citizens, and to continue this work beyond their life at university.

Introduction: Inter-university collaboration to develop innovative sustainability curriculum

This chapter details how two Australian universities have taken SDG 12 as a basis for developing a Transdisciplinary Living Lab (TDLL) to tackle the challenge of food waste production and management within the university campus and in the process, prepare design students to be active, engaged citizens beyond their life at university. The aim was to facilitate students to learn and practice design in a socially responsible manner, reflecting the rise of academic debate and teaching in the areas of social design, sustainable design, ethical design and design futures (Resnick, 2016).

The chapter draws on two years of experience by the authors in developing a TDLL at the University of Technology Sydney and Western Sydney University where the on-campus food waste management system was used as the context for transdisciplinary learning by third year design students (from Fashion and Textiles, Visual Communication, and Product Design degrees). The following chapter will first provide a background context for the two universities involved in this project and how their commitment to the SDGs has resulted in the development of curriculum to sustainably manage food waste on-campus. We then summarise the problem of food waste globally, and how the issue is linked to SDG12, before presenting the three stages of design and delivery of the TDLL.

Background context to our universities' commitment to the SDGs

In 2016 and 2017 respectively, the University of Technology Sydney[1] and the Western Sydney University[2] signed a formal commitment to the SDGs and the associated 169 targets. The Commitment was organised by the Australia Pacific network[3] within the global Sustainable Development Solutions Network[4]. The network is a United Nations initiative which links and amplifies the role of Universities in achieving the SDGs. The University Commitment to the SDGs recognises the significant role of Universities in collaboratively realising the SDGs:

"*Universities will have a vital role to play in addressing these critical global challenges and achieving the Sustainable Development Goals. Universities have a responsibility through their* ***teaching*** *to equip the next generation of leaders, innovators and thinkers to understand the global challenges facing the world and the role they can play in rising to meet these challenges. Through their* ***research and training*** *of research leaders, universities are at the forefront of finding sustainable social, economic, environmental and technical solutions to global problems. Finally, through their own* ***operations*** *universities can pioneer innovation and can set an example to other sectors and businesses*" (UTS, 2016).

This Commitment underscores the importance of integrating educational goals with the everyday experience of campus life.

[1] www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/news/ending-poverty-protecting

[2] www.westernsydney.edu.au/newscentre/news_centre/more_news_stories/western_sydney_university_commits_to_un_sustainable_development_goals_2030

[3] http://ap-unsdsn.org/regional-initiatives/universities-sdgs/university-commitment-overview/

[4] http://unsdsn.org

As discussed below, the TDLL integrates the three opportunities identified in the SDG Commitment (bolded above) into one collaborative learning experience. Combined, the TDLL and the communication of the results though the writing of this chapter contribute to the five agreements in the Commitment, namely that the universities involved will:

- "*support and promote the principles of the Sustainable Development Goals*
- *undertake research that provides solutions to sustainable development challenges*
- *provide the educational opportunity for our students to acquire the knowledge and skills needed to promote sustainable development*
- *contribute to the achievement of the Sustainable Development Goals by ensuring our campuses and major programs are environmentally sustainable and socially inclusive,*
- *report on our activities in support of the Sustainable Development Goals*" (UTS, 2016).

The food waste problem – locally, globally and campus-wide

The food waste issue is not only a problem at local and campus-wide scales. Globally it is estimated a third of all food produced for human consumption is lost or wasted which amounts to approximately 1.3 billion tons per year (FAO, 2011) across the supply chain from agricultural production through to household consumption. The severity of the food waste problem is acknowledged in Sustainable Development Goal (SDG) 12 which focuses on "*responsible consumption and production*"[5] with the goal of:

- *substantially reducing waste generation through prevention, reduction, recycling and reuse and*
- *halving per capita global food waste at the retail and consumer levels and*
- *reducing food losses along production and supply chains, including post-harvest losses by 2030*

Recognising the complex inter-relations between the goals, the mechanisms for addressing food waste also influence goals related to Zero Hunger (2); Good Health and Well-being (3); Clean Water and Sanitation (6); Sustainable Cities and Communities (11); and Climate Action (13).

Taking into consideration the significant issue of food waste at local and global scales, the University of Technology Sydney installed infrastructure and technology to manage 100% of the food waste produced on-campus through industry funding in 2015. In addition to the technological management of food waste, university-wide staff and student educational workshops on reducing food waste were conducted, along with a semester-long course for a diverse range of design students focussing on designing innovative solutions to food waste on campus.

In response to this industry-supported design program, the authors developed a model for a Transdisciplinary Living Lab (TDLL). The TDLL sought collaboration with industry, government and university operational staff, and also provided an opportunity for students to engage with the Sustainable Development Goals (SDGs) and the closely related concept of planetary boundaries while fulfilling their course requirements. The decision to incorporate the SDGs and the concept of planetary boundaries into the TDLL model was made to encourage students to critically reflect on the impact of their design solutions on global systems, in this case – food waste management systems. In addition, the TDLL helped to meet the two universities' commitments to the SDGs outlined above.

When Western Sydney University became a signatory of the UN's Sustainable Development Goals (SDGs), a number one priority was to make this commitment visible via sustainability focused campus Living Labs. Western Sydney University has a long history of experimental initiatives that have taken advantage of Western Sydney University's large, peri-urban campus to showcase best practice environmental management in an educational setting,

[5] http://www.un.org/sustainabledevelopment/sustainable-consumption-production/ (accessed 28/08/2017)

including the Hawkesbury Water Recycling Scheme, Western Sydney University Farm and the historically significant River Farm, championed by the University's Office of Sustainability. This history provides an ideal context for TDLL initiatives to build on, particularly across the University's multiple urban campuses. It also offers a unique setting for cross-institutional collaboration. For example in 2010-11 the Design and Agriculture faculties collaborated on the project 'Transitioning to Sustainable Sanitation Futures' (Mitchell et al 2012), which had a proto-TDLL format involving academics, industry and students from a range of disciplines in a journey of complex and collaborative problem solving (Lopes et al 2012).

Translating commitment to the SDGs into practice: The Transdisciplinary Living Lab

In defining the TDLL, we must first define transdisciplinarity. The term 'transdisciplinarity' (TD) has no single unified meaning (Jahn et al 2012), it can, as Pohl (2011, p.98) suggests, be perceived as a *'structured plurality of definitions'*. Reiterating this idea, Ison (2017) observes that different histories have given rise to different understandings of TD. Riedy (2017) defines transdisciplinary research as a *'bundle of interwoven social practices that takes different forms in different local and historical contexts'.* While there is no single definition, there are overarching characteristics of TD research and practice (Jahn, 2012). Wickson et al (2006) identify three primary characteristics of transdisciplinary research, that is, (1) it is problem focused, (2) it has an evolving methodology and (3) it is highly collaborative and participatory in nature.

Mobjörk (2009) observes there are close similarities between transdisciplinarity and sustainable development research. They are both multi-faceted and problem focused, interested in action, deploy participatory approaches, and aim to address values and normative judgments in the name of the common good (Klein, 2017). Jahn et al (2012, p.9) goes further, noting that TD is also 'interventionist' in the way that it frames, structures, and organizes the societal discourse about the problem being addressed.

While *observation* may provide a way of examining 'what is', research taking an *interventionist approach* goes further to ask 'what could be' (Brown, 2010). In the context of the TDLL, the question is what could a sustainable food (waste) system look like in the future, and how might this be achieved? In developing educational programs a key distinction between observation and intervention is how the researcher/student reflexively understands their position in the field of research, representing a shift from 'observer' of social reality to agent of change (Fam et al 2015).

In developing the TDLL model, the authors took the view that for a student/researcher to develop a rich enough understanding of the problem being investigated to ultimately find a point of intervention, they needed to work from inside the system. Utilising the campus as a living laboratory provided the context for students to engage with the food waste system daily and to further investigate both the visible and commonly invisible components of the system i.e. technologies, actors (cleaners, facilities personnel) and practices.

Experiential, problem-focused learning, which is deeply rooted in local context, has been theorised and practiced since the turn of the century (Dewey 1938). However the specific concept of the "Living Lab" is more recent. The Living Lab concept, which first appeared in academic literature in the 1990s, is often credited to William Mitchell, a professor at Massachusetts Institute of Technology (Dutilleul et al 2010, p.63). Mitchell identified that contemporary information technology provided an opportunity for monitoring human interaction with innovations outside of the typical laboratory environment. His approach towards researching these innovations shifted from "*in vitro* to *in vivo* settings" (Dutilleul et al 2010, p.63). This initial model of the Living Lab was described as providing a space where designers and researchers could observe users and test models through hypotheses. This concept later evolved into utilising campus space specifically as a location for these innovation models to be tested.

Dutilleul et al (2010, p.64) propose five distinct meanings to the term "Living Labs":

1) "In vivo monitoring of a 'living' social setting."
2) An "innovation system" composed of multi-disciplinary networks working in collaboration to solve a research problem.
3) An approach in which users are engaged within a product development process.
4) A term used to describe the organisations which facilitate and maintain a collaborative research network.
5) A descriptor for the European movement which emerged in the mid-2000s as a co-ordinated and common innovation system between European research networks.

Of these meanings, "Living Labs" is now commonly understood to be a fusion of the first three: a collaborative test of an innovative approach to a problem occurring in a "living" social environment where end-users are involved (Daniel 2017, p.2). This fusion of the concepts is often still separated in the literature around Living Labs. Curtis (2015, p.4), for example, proposes that a split in the literature occurs around the Living Lab as a "physical space where subjects are embedded into real-life situations, examined and included in the co-creation of knowledge"; or, the Living Lab as an "organisational arrangement involving multiple stakeholders that carry out testing, research or knowledge-creation." In order for the Living Lab process to be best understood, it is vital to consider these elements as an integrated and cohesive whole (Daniel 2017, p.2).

The Living Lab concept is increasingly being used to explore the multi-dimensional and dynamic (or 'wicked') nature of sustainability-related problems in a university setting, as a university community is inclined to nurture innovation. The socially and geographically bounded context can help to rein in complexity (or at the least, render it observable). This also ushers in a new approach to learning, where students can "discover[…], examine and fail" in a "safe environment" and that the exchange of knowledge supported by Living Labs taps into the underutilised "brain power" of the entire university, including its stakeholders (Graczyk 2015, p.32). The university has the potential therefore, to act as a local focus point for broader global concerns such as is represented by the SDGs. We can see a strong relationship between the sustainability-focused Living Lab and Jahn et al's (2012) characterisation of transdisciplinarity. Problems are discovered rather than solved, which makes the Living Lab an ideal context for transdisciplinary learning and normalizes education for sustainable development.

The relationship between 'transdisciplinarity' and living laboratories is not new. For example, Scholz and Marks (2001, p.251-52) have advocated for 'transdisciplinary laboratories' where scientists and practitioners work together for mutual benefit over periods of time. The novel approach taken by the authors is in implementing 'transdisciplinary living laboratories' as an educational platform and site for mutual learning of university operational staff and students. The expanding location of transdisciplinary research has the potential to *'heighten awareness of the public space, and amplify the concepts of deliberative democracy and socially robust knowledge'* (Klein, 2017, p.12).

Operationalizing the Transdisciplinary Living Lab Model (TDLL)

The TDLL was designed and delivered to students in three distinct and iterative stages (see Figure 1.) which included:

(1) *Entering the living lab:* introducing collaborative teamwork processes, expectations of joint problem formulation and critical reflection on students' impact on the food waste system
(2) *Transdisciplinary learning:* introduction to the concept of co-producing and integrating knowledge in collaboration with transdisciplinary partners and actors in the system and research as a process of system intervention

(3) *Global context:* introducing the SDGs and planetary boundaries as guiding frameworks to develop, refine and justify final designs, articulating global impact of local practice and defining the implementation and assessment of societal and scientific outcomes of the final design solutions.

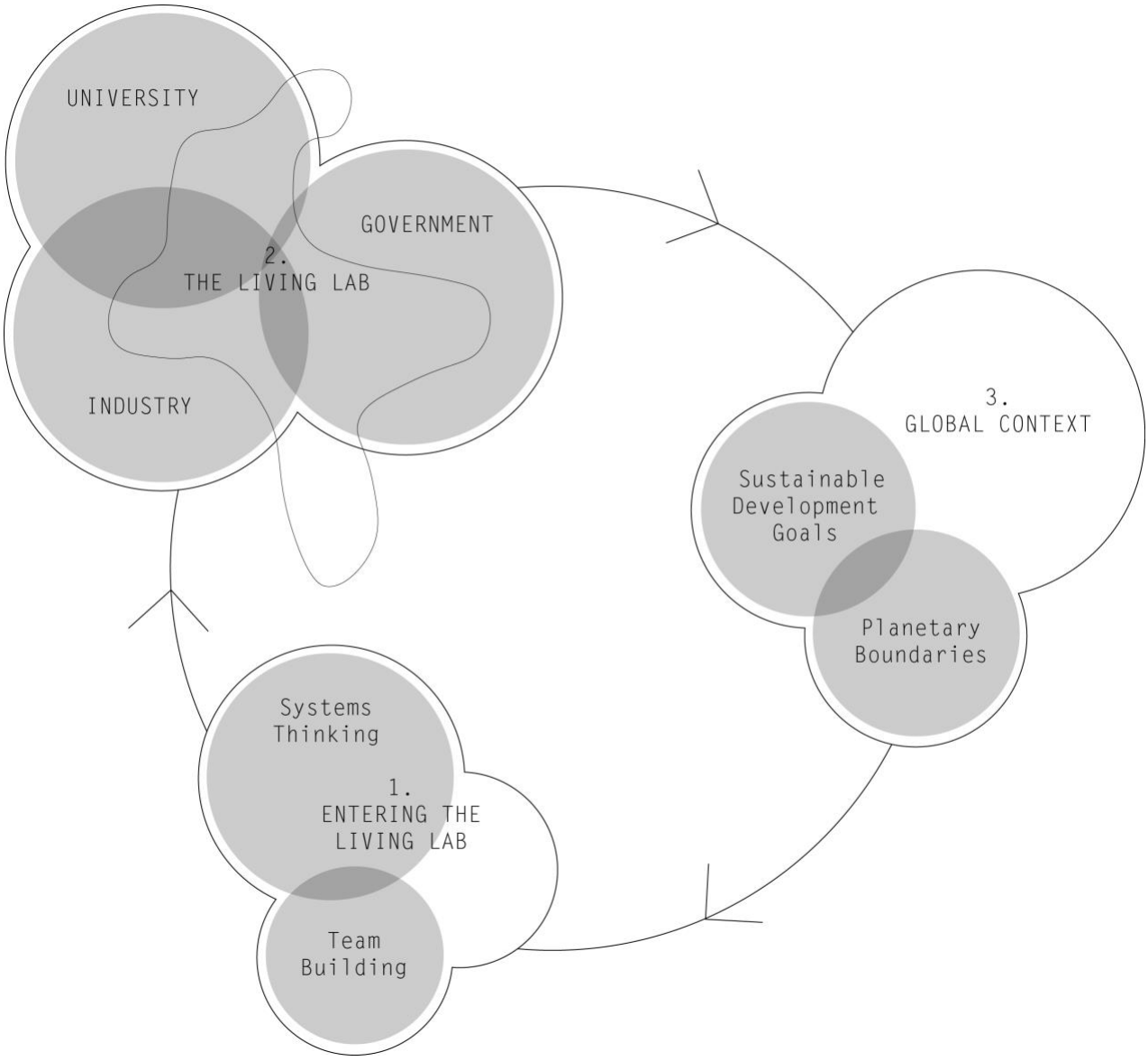

Figure 1. Overview of key stages of skills development in the Transdisciplinary Living Lab model (Adapted from Hummels, 2011)

Our approach in the TDLL was to integrate critical TD skills including collaboration, communication and knowledge integration (Fam, 2017) with design specific competencies to generate a system-sensitive design curriculum. The TDLL not only required students to develop design interventions/improvements to complex challenges (such as food waste) but also consider the broader impact of their designs in regard to the SDGs and planetary boundaries. The TDLL model was developed and iterated as a third-year design studio (2016, 2017) closely involving students, industry, government, facilities management experts and design and sustainability

academics who collaboratively worked toward more effectively managing food waste on-campus, with the long-term goal of processing 100% of the food waste for productive reuse within the Sydney precinct. With feedback from, and interaction with, expert stakeholders, design students worked in teams of 4-6 members to jointly develop briefs and design interventions.

The practice-based nature of the TDLL was supported by the NSW Environmental Protection Agency which was involved in not only funding the installation, research and evaluation of the viability of a food waste management technology on-campus, but also participated as expert panel members.

As a publically accessible output, the TDLL adopted a continuous online class blog (See: https://wealthfromwaste.wordpress.com) and Instagram feed (See: https://www.instagram.com/wealthfromwaste/), where students and educators share research, ideas, reflections and feedback on designs in a dynamic open forum. The blog created an archive of on-going learning with consecutive cohorts of students, challenging the idea that a problem, such as food waste management, can be solved within a set period of time. The TDLL proposes that sustainability-oriented challenges are an on-going process of learning and adaptation, rather than an end goal. In addition, the TDLL blog encouraged students to build on previous iterations and learning of the project, rather than 'reinventing the wheel' each time the subject is offered.

PHASE 1 Entering the living lab: Scale matters

The initial phase and entrance into the TDLL had two goals. Firstly, to encourage students to articulate a form of teamwork and collaborative research that was appropriate for team members and in the process, identify individual strengths, weaknesses and potential contributions each participant might make to the project. This required students to reflect on and document how they planned to collaborate across design disciplines and as a group, and how they would approach decision-making and collaborative research. This process was formalised in an agreed upon document which clearly defines how team members will work together, overcome inherent challenges and jointly formulate problems and potential solutions.

The second goal of this phase was to encourage students to identify their own individual contribution to food waste on a daily basis, both on-campus and within their own homes. In the process, they further developed design skills such as critical self-reflection, systems diagramming/thinking, self-auditing and environmental auditing. Students conducted self-audits of all the organic waste streams they produced within a 24-hour period and reflected on embedded habits, values and beliefs in managing waste streams more broadly. While auditing is a practice conventionally associated with accounting, it was adopted as a way for students to document and categorise their waste as individual components inseparable from broader food waste systems. This facilitated students to identify and position themselves as complicit actors, as well as agents of change, in the food waste system. Design skills were used in the self-auditing process with mapping, photographing, documenting, quantitative calculations and journaling of food waste produced. This sensitised students to the theme of the studio and primed them to identify food waste on campus as part of a broader urban food system ecology within which they are intimately involved and implicated. From a transdisciplinary perspective of skills development, self-auditing exercises prime students to question what 'valid data' are, and whose perspective should be valued. Focusing on these skills helped students to recognise that 'digging where you stand' is a good way to start being an active political agent when dealing with complex sustainability problems (Fry 2009, p.224).

Beginning the TDLL at the microscale where individual practices associated with food waste production are revealed, encourages students to realise that scale matters and that local dynamics and cultural practices are crucial to investigate when aiming to intervene in a system. The first step in comprehending the enormity of the food waste challenge and its environmental, social and economic impact is to reflect on one's own contribution to the problem under

investigation. The weekly audits provided the first step in comprehending the mutli-scalar challenge (See below for examples of food waste audits).

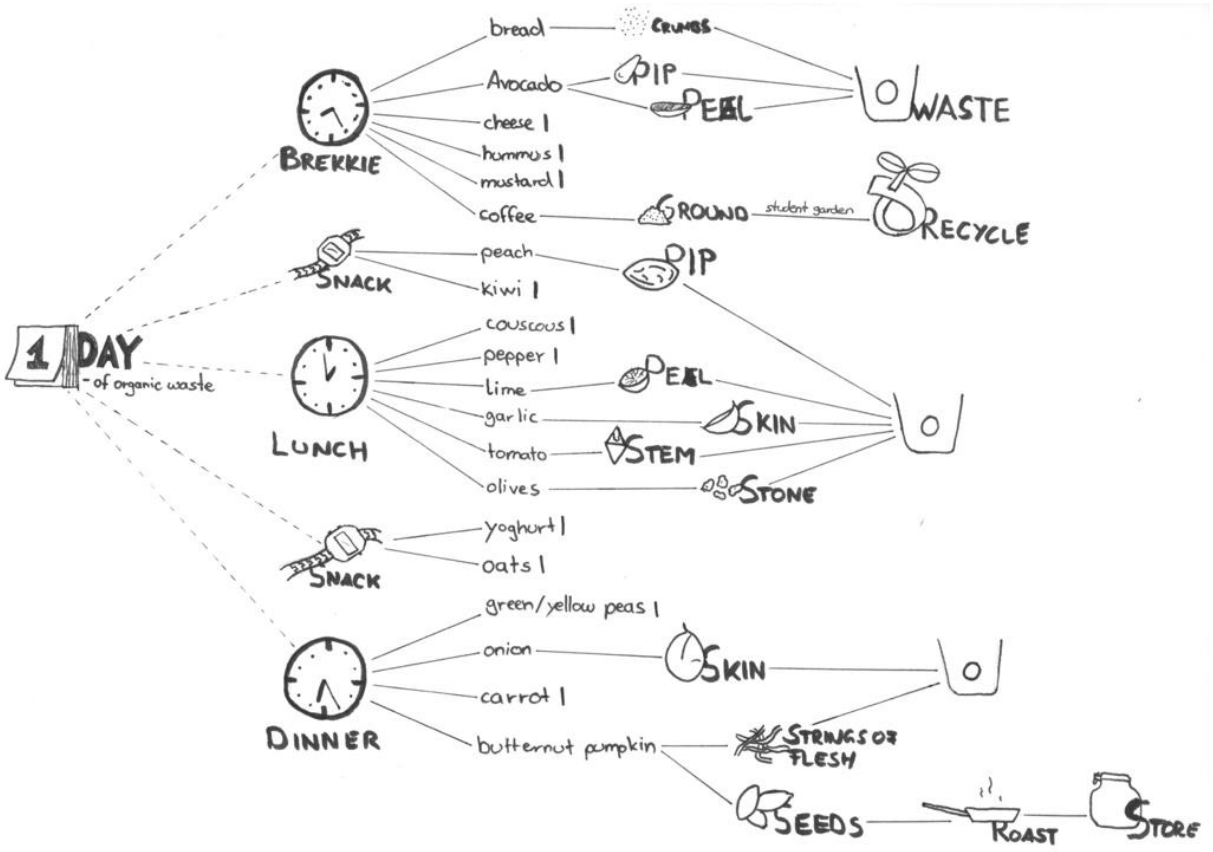

Figure 2. 24-hour self-auditing exercise - Student work

The first phase of the TDLL model frames the microscale as critical for understanding how they might intervene in a system of food waste management by exposing students to their own cultural and everyday practices, inconspicuous habits of consumption and waste production rates. The following stages build on the microscale and introduce students to multi-scalar influences on food waste management i.e. university, local city, state-wide and regional influences. Relationships between macro and microscales, and the interactions between macro-structure and micro-agency affect the way waste is managed. Improving the understanding of linkages between microscale and macroscale phenomena and impacts is an intellectual challenge for students to grasp and was introduced in the following stages by incorporating reflection on SDG 12 and planetary boundaries as a guide for final design solutions.

PHASE 2 Transdisciplinary learning: Multi scalar perspectives

Once students had entered the TDLL, reflected on their own role in the food waste system and learned to negotiate team dynamics, the second phase was spent gaining insight into the food waste system from multiple disciplinary and lay perspectives. This was achieved through collaborative expert panels, Q&A sessions and evaluation of student progress by project partners and industry and government experts. Importantly, the end-user perspective of the system was sought, with students invited to produce primary research data to support and justify their final design interventions. Students drew from a range of system thinking tools and methods including stakeholder mapping, 'rich pictures', and causal loop diagramming to facilitate teams to initially

identify their own knowledge of the system, interactive components and critical actors in the system. Primary research methods included interviews, surveys, shadowing cleaners to identify everyday cleaning practices and participatory observation.

Taking the position that a variety of different perspectives on the issue of food waste management on-campus provided a richer problem context, the authors engaged an expert panel to work with students over the duration of the TDLL. This was achieved in a number of ways, most successfully through a half-day presentation and Q&A where representatives from local council, the NSW EPA, technology developers and UTS facilities management staff provided their own perspectives on the issue of food waste as well as identification of where innovation is currently occurring and is expected in the near future. Student engagement with expert stakeholders in the system provided not only multiple perspectives, but also insight into contested viewpoints, values, approaches and personal and organisational commitments to creating change while allowing students the opportunity to further develop skills in critical listening, thinking and reflection.

The second phase encouraged students to view waste from a 'multiscalar' perspective, as a result of a complex global, national, local, and individual set of processes and practices. It also examined the often hidden dynamics involved in creating the conditions for the regulation and management of waste.

PHASE 3 Global context, local practices

Phase 3 of the process required students to justify their final designs in relation to the methodological approach, knowledge gained throughout the process (including the global context) and TD skills developed i.e. collaboration, communication (in its multiple forms) and attempted integration of knowledge through a collaboratively developed design solution.

In this phase of the TDLL in 2017, students were introduced to the broader global context, including the concepts of the SDGs and the planetary boundaries, e.g. the idea that there is a need for humanity to function within the boundaries of a safe operating space (Rockström, 2009). This introduction had two aims. Firstly, to broaden the perspective of the problem of food waste beyond the campus to city, state, national and global scales, making the boundaries of the Living Lab porous. Secondly, to support students to leave the lab with insight into the interdependences and impacts associated with system design. Students were therefore invited to reflect on their own design interventions to improve the food waste management system and how their designs took into consideration the broader global context of planetary boundaries and SDGs.

Engaging with the SDGs and Planetary Boundaries in 'Three Acts'

The engagement of student/researchers with the broader global context was delivered in three Acts.

Act 1 explored how the earth systems which support the emergent property of 'life' (Capra, 1996) are severely disrupted. Included in the discussion were the concepts of The Anthropocene (Lewis and Malsin 2015); The Great Acceleration (Steffen et al 2015); The Tipping Points (Rockstrom et al 2016); and The Planetary Boundaries (Rockstrom 2009). As much as possible, the explanation of these concepts included a specific grounding within the concept of food waste. For example, in discussion of the Great Acceleration, the social and environmental trends relating to food production and waste were identified. The Anthropocene identifies significant changes caused by human activity in the atmosphere, ocean, land and life, including changes in the Nitrogen cycle. Through use of a mind-map, the specific linkages between changes in the Nitrogen cycle, and food production/waste were explored. After introducing and offering examples of the nine planetary boundaries, the student/researchers were then tasked with making the connection between dealing with food waste and potential impacts on the planetary boundaries. After the activity, student/researchers were asked to reflect on:

- To what degree does the food system interact with the planetary boundaries, and why?

- Why is dealing with food waste important from a planetary perspective?
- How was that exercise helpful (or not) for you as a designer?
- What are the different levels at which designers can engage with the planetary boundaries?

These reflections highlighted the challenges of engaging design students in what can be difficult and complex scientific concepts. Future iterations would allow more time to do this activity.

Act 2 focused on understanding the concept of '*systemic intervention'*. As mentioned above, the purpose of this exercise was to demonstrate that there are many interwoven causes and effects of food waste within campus, and that designing an intervention is most effective when the system has been mapped and observed. To begin mapping the system, students undertook a root cause analysis for the question: What is driving food waste at UTS? In this analysis, mind maps were created by asking "why" for all of the different answers to this question, five times. The students were then invited to add these insights to causal loop diagrams they had created earlier in the semester on the food waste system on campus (e.g. systems thinking was interwoven through the whole semester).

Students were introduced to Donella's Meadows notion of leverage points for change in a system (1999; Abson et al 2017). We discussed example levers of change for each of the high-level system characteristics (e.g. parameters, feedbacks, design, intent). For example, we discussed how 'the price of food' is a parameter, and how this lever for change can influence the food waste system, whereas on the other end of the spectrum, we discussed several food waste paradigms, i.e. There is an 'away' to throw food waste to, and what different scale of impact would be by addressing paradigms governing the systems verses parameters within the system.

Based on the global context of **Act 1** and the notions of designing systemic change in **Act 2,** the Act 3 focused on designing '*glocal' interventions* (globally aware, yet locally relevant). The context for **Act 3** included the introduction of the Earth Charter and the Donut Model (a safe *and just* operating space) (Raworth, 2017), and the introduction of the SDGs. Here the history of the development of the SDGs, the purpose, and the adoption by Australia and the universities involved were discussed. The SDGs were temporally contextualized by introducing the notion of The World in 2050[6], which sets the SDGs as the goal for 2030 and the planetary boundaries as the goal for 2050. Student/researchers then actively explored the SDGs, the concept of food waste and their designs. Specifically, in order to improve the impact, and explain the benefits of their designs they investigated and mapped out the relationships between the goals, targets and food waste streams. This included reflection on the following questions:

- How does addressing food waste help achieve the SDGs?
- Which **goals** and **targets** are **primary** (strongly linked) and **secondary** (less strongly linked) to addressing food waste?
- Which **indicators** are relevant to food waste management, and to what degree could the impact of your proposed design be monitored by these indicators?
- How are these inter-related?

As a final task, students were invited to develop a broader perspective on their learning through a reflection process in which they translated their TDLL experience into a prospective job application on the class blog, highlighting the skills developed and experience gained during the TDLL. This became an opportunity for the authors to evaluate not only how students had incorporated a 'global perspective' on the potential impact of their final design solutions on the planet, but also what – from their own admission – had been the greatest learning experience and the most valuable skills developed.

One student commented: *One of the most influential moments I've experienced was to [learn]… about the Sustainable Development Goals (SDG). I personally think that design has a*

[6] https://rethink.earth/the-roads-to-2050/

power to change one's mind, therefore, I needed to understand how habitual changes regarding food waste…disposal in general impacts us as a nation. In total SDG focused on 17 goals to achieve in the next 15 years, which opened my eyes to the possibility of design solutions in which I would love to contribute.

Conclusion

The conventional domain for many universities to address sustainability lies within schools of the environment, focusing primarily on resource management (Hoffaman et al 2017). In contrast, Living Labs allow for the development of different models for sustainability education that operate within and across university faculties (and inter-university collaboration). The challenge of introducing and standardising collaborative research across disciplinary faculties in degree programs (Fam et al 2018) attests to the need to consider and nurture multiple models of inter- and transdisciplinary education, of which a TDLL is one.

In the higher education context, on-campus Living Labs are one way to create an environment that supports TD research. Living Labs bring members of the public, business, government and researchers together to co-create services, systems, technologies and societal solutions. Linking curriculum, operations and research, Living Labs offer holistic and systemic ways to support the university, and its researchers, students and graduates to practically meet the SDGs (Reynolds, et al 2018). Utilizing campus infrastructure as a living environment for applied, collaborative learning not only advances sustainability on campus but prepares students to be active, engaged citizens, and to continue this work beyond their life at university.

On a final note, as educators, the authors believe that '*…a fundamental change is needed in the way we think about education's role in global development because it has a catalytic impact on the well-being of individuals and the planet' (Irina Bokova, Director General of UNESCO, UNESCO, 2017).* This chapter has aimed therefore to share our experience of designing and delivering context-dependent, collaborative learning experiences that incorporate the SDGs and planetary boundaries not only as a concept for reflection by students but as a guiding frame for designing a more sustainable world.

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