WHAT WILL IT TAKE FOR COMPUTING TO SAVE THE WORLD?

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SUMMARY

This paper describes the application of a transformation mindset to guide the development of Computing for Sustainability.

BACKGROUND

In this paper we describe the use of Mann *et al.*'s (2017) Transformation Mindset to a consideration of why computing has struggled to deliver substantial change in the overall project in achieving sustainability.

Myers and Nathan (2016) describe current attempts to address sustainability through computing as "impoverished", by which they mean that it "largely fail(s) to represent the complexities of, and in particular the plurality of perspectives on, sustainability" (p229). In a similar vein, Silberman *et al.* (2014) explored the "next steps" for sustainable human computer interaction (HCI) and found that "business as usual (is) not well positioned to contribute substantively to efforts to address the challenges of sustainability" (p66).

It is difficult to estimate the impact of computing actions towards sustainability. Hilty *et al.* (2017) points to a lack of a non-computing baseline. But is undeniable that computing has the promise of being a leverage discipline. The potential handprint of computing is far greater than its admittedly large and troubling footprint.

Berkhout and Hertin (2001) introduced the distinction among first-, second- and third-order effects of ICT, (1) "direct environmental effects of the production and use of ICTs", (2) indirect environmental impacts through the change of "production processes, products, and distribution systems", and (3) indirect environmental impacts "through impacts on life-styles and value systems" (2001).

Considering a limited set of Greenhouse gas emission abatement levers, Hilty *et al.*(2017) estimated the potential handprint being 2.6 times greater that the footprint. This handprint is largely attributed to 2nd order efficiencies which Berkhout and Hertin described as "largely positive through decoupling of economic growth and environmental damage"

- intelligent production processes
- intelligent design and operation of products
- reorganisation of supply chains and business organisation
- intelligent logistics and distribution
- process of e-materialisation
- networking effects facilitation of codified information

But, pointing to the productivity paradox, they are wary of being overly optimistic

- resource productivity gains are slow
- scope for e-materialisation may be limited
- incomplete substitutions
- interrelationship between the virtual and the material economy

Mann and Bates (in press) discuss how the promise of computing's potential positive impact has led to a vision of "apps that tell you how long you've been in the shower (that) are going to save the world". They ask ,"if it was going to save the world, how come the world's not saved yet?" and argue that "worse than being ineffective, the focus on computing supported efficiencies are actually doing us harm". They list eight reasons for this: appealing to the wrong value sets; green myths (or Geek Heresy); substitution; negative focus (rather than regenerative hope), context of sell more stuff; rebound; the nature of sustainability not being amenable to positivist intervention; and a weak understanding of sustainability (Krumdieck and Mann 2015, Hes and du Plessis 2014, Toyama and Mann, 2015). The last "weak sustainability" refers to the technical term - as opposed to Daly's strong sustainability, but also meaning limited understanding of sustainability. Computing seems to have gotten totally distracted by carbon, framing sustainability as only carbon efficiency for climate change through 1st and 2nd order efficiencies.

Climate change is indeed a defining issue of our age, but framing computing for sustainability primarily in that way ignores all the other important elements. How can computing help biodiversity loss, global inequities, or intergenerational inequities? These t hings are complex systems posing wicked problems with intergenerational timescales, so while we have an approach to computing for sustainability which is focusing primarily on simple, short term things that we know we can fix, we're not going to get there.

This should not come as a surprise though, Hilty *et al.* (2017) point out that their analysis of environmental impacts was limited to GHG emissions: "ICT also has other economic and social effects, which were not within the scope of this study. The climate change impact of ICT is one part of the picture and needs to be complemented by other perspectives". (p35)

It would be defeatist to think that a holistic sustainability is too hard to approach from a computing perspective, but rather, we argue that a different mindset might provide a way forward. In the following section we apply a Transformation Mindset (Mann *et al.* 2017) to help consider and progress the contribution of computing to a sustainable future.

TRANSFORMATION MINDSET

Mann *et al.* (2017) developed a Transformation Mindset as a means to guide practitioners in adopting being a sustainable practitioner as part of their professional framework of practice (Mann, 2011 p13).

Mann *et al.* (2017) defined the "Transformation Mindset as a way of thinking that leads to transformational acts resulting in socioecological restoration". This transformational focus came from Leach *et al.* (2012) who argued that "what is now needed is nothing short of major transformation – not only in our policies and technologies, but in our modes of innovation themselves – to enable us to navigate turbulence and meet Sustainable Development Goals".

While some avoid a problem formulation, preferring a positive framing of opportunities (Hes and Du Plessis 2014 - a baby is not a problem but something precious to be nurtured), the challenge posed by unsustainability can be usefully considered as a "wicked problem" (Morris and Martin, 2009). This means it involves complexity, uncertainty, multiple stakeholders and perspectives, competing values, lack of end points and ambiguous terminology. It means

dealing with a mess that is different from the problems for which our current tools and disciplines were designed. As individuals and disciplines , we are ill-equipped to cope with the messy complexity we now face. Adomssent *et al.* (2007) saw sustainable development from a holistic perspective; it can be understood simultaneously as a concept, a goal and as a process or strategy. The concept speaks to the reconciliation of social justice, ecological integrity, and the wellbeing of all living systems on the planet. The goal is to create an ecologically and socially just world within the means of nature without compromising future generations.

We posit that a sustainability-based transformation mindset may be beneficial on the following premise: Sustainability is the process or strategy of transformation toward a sustainable future, and the transformation mindset as providing a structuring for that and therefore for providing guidance for disciplines such as computing.

Mann *et al.* describe the sustainability-based transformation mindset (Figure 1) as follows:

> *The mindset can be considered with a device recognisable to those familiar with software engineering's Agile Manifesto – a list of values and attributes arranged so that each is defined in part by an opposing value (Beck et al. 2001). The agile manifesto structure finishes with "that is, while we value the items on the right, we value those on the left more" (np). These things on the right then are not inherently wrong – we could find people attempting sustainability doing those things, but we argue that the things on the left are better. Hence, for example in The Transformation Mindset, Item 7, "values change over behaviour modification" can be read as 'we value things that modify behaviours, but a focus on values change (and hence behaviour) is stronger'. Most of these items also carry more than one message. Item 7, for example again, also speaks to the problem of change by appealing to inappropriate values such as promoting "green" actions because it is cheaper rather than because it is the right thing to do (otherwise, what happens when green turns out to be more expensive?).*

If we wish to transform ourselves and society, we need to embrace

1. Socioecological restoration over economic justification
2. Transformative system change over small steps to keep business as usual
3. Holistic perspectives over narrow focus
4. Equity and diversity over homogeneity
5. Respectful, collaborative responsibility over selfish othering
6. Action in the face of fear over paralysis or wilful ignorance
7. Values change over behaviour modification
8. Empowering engagement over imposed solutions
9. Living positive futures over bleak predictions
10. Humility and desire to learn over fixed knowledge sets.

Figure 1: Transformation Mindset

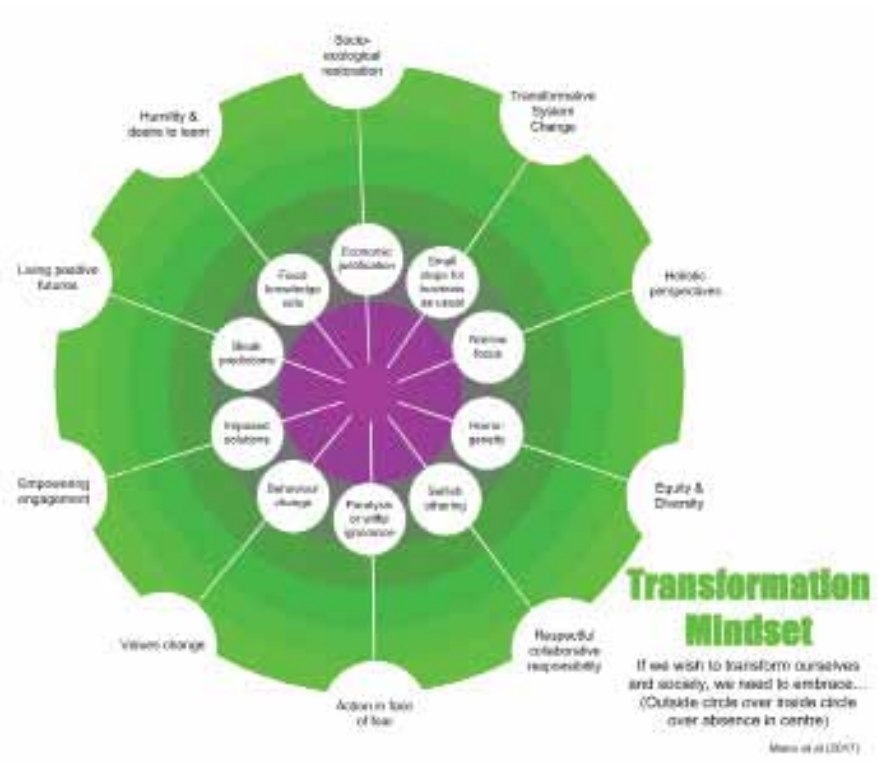

Figure 2: Graphical version of the Transformation Mindset

While each item can be considered separately, they are not exclusive and tensions between the items provide much of the challenge. The elements of the Transformation Mindset are further explored in relation to computing in the sections below.

The Transformation Mindset can be used to consider different development initiatives. Figure 2 gives a graphical version of the Transformation Mindset in which the elements of the mindset can be positioned on the 10 axes. Note that in keeping with a mindset rather than a detailed set of metrics, the positioning on each axis is subjective. For each, the inner ring describes actions that usually align with a weak sustainability, and the outer ring a transformational approach. The centre of the image, inside the inner ring represents actions that could be considered unsustainable, or where that element is not addressed at all by the development. As the arrangement of the axes around the circle is arbitrary (clockwise from the top) no inference can be drawn from particular shapes on the diagram. Further, it would be inappropriate to attempt to calculate a total "score" - that is, you can't make up for not attempting socioecological transformation by maxing out equity or some other element.

As an example of the application of the Transformation Mindset, Figure 3 shows a business development to help homeowners manage smart home equipment, primarily solar panels (unpublished project). Again, as an actual development, the project scores better for "Action", on "Positive futures" for enabling homeowners to live more sustainably, and on "Transformative system change", but not so well in other areas. In diversity it performs poorly for being a one-size fits all, forcing homeowners to fit the system, rather than enabling everyday practice. The system is primarily marketed as saving money as a means to change behaviour so performs poorly on "Value change".

1. Socioecological restoration over economic justification

This item makes clear that the point of sustainability is socioecological restoration. Economic development or reasoning is not dismissed but should be seen as a means to achieve benefits in social, cultural and environmental aspects – a vehicle for sustainability, not a goal in itself (this aligns with Daly's Strong Sustainability, 1996).

The combined socioecological wording is a deliberate modification of Olsson *et al.*'s (2004) "social-ecological" to bring it in line with constructs such as "socioeconomic". It represents an acknowledgment that humankind and the environment are inseparably intertwined. Sustainability is not just about single factors such as efficiency gains, and the problem is not just about carbon or energy; the systems in question are as much social as they are biophysical.

The restoration element is both an acknowledgment of the current path of degradation and a commitment to repair, not just stabilise or maintain in a degraded state (Hes and du Plessis 2014).

Figure 3: Smart home power management considered by Transformation Mindset

2. Transformative system change over small steps to keep business as usual

It is widely argued that making small improvements, while maintaining the status quo, is unlikely to result in required changes for a sustainable future (Placet *et al.*, 2005).

Transformation is used here to move the focus beyond the comfortable perception that global environmental challenges can be met through marginal lifestyle changes. Small changes are necessary but insufficient – we live at a time when we need urgent and ambitious changes (Thøgersen, 2009). Instead of solely working on small things and hoping that they add up to a change (themselves or with 'spill over'), we need to focus on things that multiply to create positive system change.

While looking for system changes, we need to be careful not to put too much reliance on "miracle cures". While this may seem to contradict the purpose of this paper, "What will it take for computing to save the world ?". The clue is, that computing is tool that facilitates and enables social change, rather than a technological saviour. Waiting for technology to deliver efficiency gains through behaviour change, or even not having to change behaviour, is what Krumdieck (2015) refers to as a green myth. It's the miracle just around the corner so we can carry on business as usual. Kentaro Toyama (2015) has a similar concept in his "geek heresy", that we think that throwing technology at problems is going to solve them, but his summary is technology exemplifies underlying human forces. If we are continuing to consume, and that's the primary human force, then throwing technology at it is not going to solve that problem.

Figure 3 shows the mindset applied to a product development intended to digitise a previously paper-based process - that of building consents processing within a local authority. This project had been described as meeting sustainability objectives. The project does not score highly on any of the Transformation Mindset elements. While it is doing something, it is narrowly focussed, not participatory and focusses on monetary benefits for action. While it may save some paper, this is substituted with IT equipment. The project made no attempt to address diversity (eg through language, disability accessibility) and by standardising process, inadvertently made it harder for non-standard community processes.

Figure 4: Digitisation of process for building consents

Figure 5: Digitisation of process for fisheries management.

The impact of the socioecological and transformation elements can be seen in comparing Figure 4 and Figure 5. Figure 4 represents the application of the Transformation Mindset to a project for local government to digitise the paper-based process of managing building consents. Although the primary driver for the work was efficiency in terms of time, it was also seen as contribution to sustainability (through the elimination of paper). The project though was essentially a business as usual - there was no attempt to eliminate site visits, or enabling of self-reporting by builders. In imposing a solution it had the unforeseen consequence of making some processes harder. The development of a digitisation of a environmental management system for fisheries management (Figure 5, Maxwell *et al.* 2014), by contrast, was designed to enable a system change. While the process replicated a paper-based process, the focus on integrating the benefits so that the information had value for the fishers lifted the process from being one of compliance to adding sustainable value throughout the whole supply chain - from net to plate.

3. Holistic perspectives over narrow focus

This item refers to bigger-picture thinking. This bigger picture applies to time, space, disciplinary boundaries, species boundaries, approaches to inquiry and so on.

Sustainability requires a systems approach (Easterbrook 2014). People need to have awareness that their actions will have impacts. These impacts may be intended and unintended, across scales: temporal, spatial, social, and have positive and negative effects. People need to understand forms of relationships (hierarchies, partnerships, feedback) and that humans form part of a complex web. Systemic thinking emphasises patterns, trends and feedback loops.

Sustainability can be described as ethics extended in space and time (Mann, 2011). This wider ethics calls for solidarity with the entire Earth, ecological sustainability, lifestyles of sufficiency, and a more participatory politics. The underlying force of sustainability as a concept is intergenerational equity but this is largely overlooked – our time spans of concern are almost always far too short.

Figure 6 shows the mindset applied to the development of a carbon accounting system (Calteaux *et al.* 2012). Using a metaphor of a smart budgeting & personal finance software as compared to the snapshot of a bank statement, the project used aimed to take a relationship-based approach to carbon footprint analysis. The goal was to have a personal carbon assistant - 'yes you can buy the new TV but you'll have to walk to work twice a week if you want to stay under two tonnes of carbon this year'. While this project did not take a wide perspective of sustainability - it was limited to carbon - it does show benefit of thinking more holistically in terms of everyday practice.

Figure 6: MyGreenFeat

Figure 7: Panda Island

4. Equity and diversity over homogeneity

For Fagan (2009), the ethical imperative is the basis of sustainability: "To live a particular lifestyle that, knowingly, impacts detrimentally on a neighbour – be that an individual living in the next house – or a country in the next Region, cannot, arguably, be tolerated. To know of poverty in the economically developing world and not use that knowledge to act to relieve it, could be considered unethical".

Diverse systems are resilient systems. The call for diversity can be seen to be in tension with the need to transform to sustainability at scale. But it does not mean a homogenous one-size-fits-all solution. Pita Tipene describes this well (2016 np) : "I think that we're all seeking to be a global community and to be truly global we need to both cultivate, strengthen and enhance the small villages that we have throughout the world. To retain that uniqueness and unity through diversity as a key."

5. Respectful, collaborative responsibility over selfish othering

Rather than shifting responsibility onto others, we need to accept responsibility and address the issues together.

Oxfam (in Parker *et al.*, 2004) described a "global citizen" (p. 68) who is, amongst other things "aware of the wider world and has a sense of his or her own role as a world citizen", "outraged by social injustice" (p. 68) and takes responsibility for his or her actions. Using the term "outraged" takes value-based and action-focused further than other such statements. This is, of course a value statement, their "citizens" are not passive but can be described as having a "sense of identity and self-esteem…a belief that people can make a difference" (p. 69). They back these attitudinal

Figure 8: CityScape

Figure 9: Citizen Science

Figure 10: Community engagement

statements with skills in critical thinking; an ability to argue effectively; an ability to challenge injustice and inequalities; and cooperation and conflict resolution.

Figure 7 shows the mindset applied to a game for teaching problem solving skills as part of a conflict resolution programme in primary schools (Sell *et al.* 2013). This posed particular challenges as most of the traditional elements of digital gameplay were considered incompatible with the goal. The skills of conflict resolution, however, align with the respectful collaboration of the mindset.

6. Action in the face of fear over paralysis or wilful ignorance

In the face of wicked ambiguity , we still need to take considered action rather than suffer paralysis or passively wait for miracle cures. We should also avoid action linked to wilful ignorance (or denial).

Most, if not all, problems of sustainability can be described as trying to address "wicked problems ": Intergenerational time scales, complex systems – that are not amenable to the short-term, positivist approach of most interventions. Instead , we need to learn to live in a complex world of interdependent systems with high uncertainties and multiple legitimate interests. These complex and evolving systems require a new way of thinking about risk, uncertainty, ambiguity and ignorance (Stagl, 2007). These systems require that we can think simultaneously of drivers and impacts of our actions across scales and barriers of space, time, culture, species and disciplinary boundaries.

7. Values change over behaviour modifications

In order to make meaningful long-term changes, there needs to be a shift in values, rather than just addressing harmful behaviours. Intervention that achieves behaviour change without corresponding values is likely to not be as effective due to dissonance felt by the individual.

Sterling (2009) describes the importance of critical reflexivity – or deep questioning of assumptions. This reflexivity, or self-reflection is crucial to the transformation mindset – we need people to care. "First you have to care," argued Attkisson (2008 p. 16) as the first step towards sustainability. We need to embed sustainability itself as a core cultural value of the system.

Figure 11: Simpa - participatory game development for Iwi cultural content

Figure 12: Participatory decision making

A values basis can be the basis for successful business. Wishbone Design Studio (Latham *et al.* 2016), for example, produces children's bikes. On Willard's sustainability maturity model (2004), Wishbone is operating at the highest level, a values basis where "sustainability-based thinking, perspectives, and behaviours are integrated into everyday operating procedures and the culture of the organization" (Willard p. 31). Wishbone is values-led, entirely based on a framework of sustainability and quality. Wishbone's primary product is a bike that lasts from ages one to five, and then can be passed on to the next young rider. The role of values infuses the business and the relationship with customers "because we declared our values early on – sustainability and quality – we were attracting customers of that same ilk, the pressure on us was not to drop standards, but to raise them" (Latham *et al.*, 2016). The challenge for computing is to develop a similarly values-led business model.

Cityscape is an immersive panoramic exhibition system developed for a local museum (Farquharson *et al.* 2010). The intention was to allow visitors to explore areas and express their creativity, building a community narrative. While the project did not have any intended transformational objectives and did not explicitly consider socioecological restoration, it is notable here for the focus on values - particularly the celebration of place and the community's relationship with place.

Figure 9 summarises the Transformation Mindset applied to the development of a citizen science app designed to improve the ocean foreshore participation and community engagement (Sime *et al.* 2012). This development scores highly on the "Values", "Empowering engagement" and "Respectful collaborative responsibility". In that the citizen science is wider than just data collection and extends to the curiosity and hypothesis formulation aspects, it also scores well on "Humility and desire to learn". It does not, however provide a clear pathway to "Transformative System Change".

8. Empowering engagement over imposed solutions

By empowering individuals and groups, and ensuring that they are engaged, any actions that are taken are likely to be more successful than if 'outside experts' impose solutions. Working with, rather than about, is vital. Ensuring that solutions are case specific and appropriate, rather than a 'catch all'. Actions should be: collaborative; participatory; equitable; open; trusting and supporting of ownership. Building self-reliance should be a goal.

Some are working on community engagement, not as a means for behaviour change, but for the sake of an empowered community: University of Lancaster's work on Tiree (Ferrario *et al.* 2014); Rob Comber's empowering communities (Comber and Mann 2015); and David Green's participatory documentary making (Green and Mann 2015). These research directions are supporting communities to create sustainable futures beyond a behaviour-change-intervention-via-new-product paradigm. Figure 10 shows one such project, PAiNT (unpublished) on the Transformation Mindset. A community engagement focus brings with it a different set of success measures. Another project, the City Wide Energy Meter, aimed at fostering discussions of long-term energy usage (Attfield *et al.* 2014), the success being defined as Community Energy Literacy being an individual's confidence to take part in community consultations.

9. Living positive futures over bleak predictions

While doom and gloom predictions can help jumpstart action, there needs to be more of a positive outlook in order to motivate and capture change. We take an optimistic frame. It is easy to become negative about sustainability. To do so, however, is to miss the point. The focus of sustainability is on the solutions, not the problems. Sustainability is the solution to living beyond planetary boundaries and a finite number of resources.

Orr (1992) argued that "the study of environmental problems is an exercise in despair unless it is regarded as only a preface to the study, design, and implementation of solutions" (p. 94). Schendler (2009) makes an important distinction. He says it is vital that we do not see the challenge (in particular climate change) as the end of the world. Instead we can see "an opportunity on the scale of the Enlightenment or the Renaissance, a rare chance to radically change the face of society forever" (Schendler 2009 p. 46). This is not to deny the problem. Rather, we would argue for demonstrating positive alternatives: transition towns, or co-housing initiatives, for example. Scott (2016) argues that the problem with the green movement is that "they assume, falsely, that change is achieved by brute logic. Change is not achieved by brute logic. It's achieved by, in fact, listen, link, leverage and lead." In other words, by leading positive change.

SimPa, first described by Mann *et al.* (2006) and summarised in review by Weatherall *et al.* (2009) was a collaborative partnership between the Otago Polytechnic and Ka Papatipu Runaka o te tai o Araiteuru. The project aimed to convey and strengthen research aspects in regard to Maori culture, tikaka and knowledge using games programming as the vehicle. (Figure 11). The approach was to develop and use a process of participatory game development for Maori cultural content. This project was entirely about enhancing diversity but in doing so scores highly on most of the elements of the mindset. While the project set out to achieve system change, the outcomes were quite different - still transformational but not what was expected.

10. Humility and desire to learn over fixed knowledge sets

The desire to learn has several implications or variations: humility over wilful ignorance; curiosity over fixed cognitive maps; challenging assumptions over accepting status quo. This then, is a learning mindset in line with Senge's (2008) argument that everything we do is a learning opportunity and Orr's (1992) description of the role of an ecologically literate population. Such people, he argued are "able to distinguish health from its opposite and to live accordingly" (p.108). A mission of education is to give something that "will equip a person to live well in a place (p. 151) But we should never be fooled into thinking we know it all.

The mindset, then, emphasises a curiosity and questioning – a desire for knowledge, but a firm belief that we can never know all the answers.

One discussion-oriented modelling system is PowerSim, a structured process for policy development using interactive visualisation and computer simulation (Randall *et al.* 2012, Figure 12). It is foremost a participatory process to engage people in thinking about issues such as those involved in the development of long term strategies. Rather than a static model, the outcome of the process is the modelling process itself – of increasing understanding,

uncovering assumptions, and in jointly recognising drivers and implications. Thus PowerSim is an example of participatory engagement in policy development. It brings together spatial thinking, systems thinking and consensus decision making.

CONCLUSION

If we take the example of Human Computer Interaction (HCI) within computing, seminal papers such as Blevis' Sustainable Interaction Design (2007) prompted a flurry of research in sustainable HCI. However, as Brynjarsdottir *et al.* (2012) found, much of the resultant research is weak and focusses on a limited framing of sustainability and human behaviour, or, as Meyers and Nathan (2016) bleakly described, with an "impoverished" focus

Aimers and Walker (2016) argue that we need to move beyond a selfish individualistic approach to one of empathy and valuing social capital. Knowles' *et al.* (2013) brings this values approach to computing and describes how the rational, economic man approach appealing to people's wallet is actually disabling the altruistic "we need to be doing this because it's what we need to be doing justification". As an example of this critical questioning, Knowles argued that work to develop computing for sustainability has been hampered by an ecological modernisation agenda – the optimistic thought that greening IT will save the world - "computing seeks sustainability wins that can be found within the dominant ideology of our technological era" but rarely goes beyond "encouraging unfettered consumerism and shallow forms of socialisation".. Knowles would rather a radical agenda that explores alternatives to "an inherently unsustainable digital economy, or challenging the instrumentalisation of the sustainability problem". She concludes that computing has "unwittingly narrowed its solution space", and that even greater opportunities for research might be discovered by going beyond the traditional energy efficiency focussed persuasive technology "to embrace more contemporary, more holistic, and more radical understandings of sustainability". Further, the nature of unsustainability means that by definition the problems aren't amenable to the experimental/intervention paradigm that computer science generally works under.

These goals are not trivial challenges for computing. Mann *et al.* (2017) described a goal of the sustainable transformation mindset is to be used to guide development initiatives. The hope is that the Transformation Mindset can provide a useful tool for computing scholars and practitioners in providing a framework for computing to contribute to a restorative socioecological transformation.

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