

World Futures Review

Alternative Futures as a Method for Sustainability Pedagogy

Journal:	<i>World Futures Review</i>
Manuscript ID	WFR-17-0026
Manuscript Type:	Original Manuscript
Keywords:	Experiential Learning, Sustainable lifestyles scenarios, Alternative futures, Sustainability pedagogy, Design pedagogy
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1. Introduction

The notion of the Anthropocene argues that 'Earth's most recent geologic time period has been human-influenced, or anthropogenic' (Crutzen 2006 Steffen, Grinevald et al. 2011). This is based on overwhelming global evidence that earth system processes are now unequivocally altered by humans — a diagnosis which serves as an urgent call to action to change the way we live. A growing body of academics and practitioners (Grin, Rotmans & Schot 2010) are advocating for transformative changes to achieve sustainability. They are aiming to address this through interventions across a wide array of levers of change (Meadows 1999) in multiple hard systems (such as energy, food, mobility, health, education, finance) and soft systems (such as fashion, culture, governance, religion, ritual).

It is now commonly agreed that these changes to create the conditions for sustainability transitions need to extend beyond the triple bottom line (Elkington 2004) to address new governance structures, social systems and societal paradigms.

At a societal level, reaching the current sustainable development goals implies that the modern urban lifestyle will need to reduce consumption by ten times (Charter & Tischner 2001). This is no small feat, and will require an ambitious re-imagining of almost every aspect of the modern lifestyle (Ehrenfeld 2008). The current context of unsustainable lifestyles and social practices has created an urgent need to develop new methods, tools and narratives (Beddington 2010).

Tackling these challenges in a meaningful way means creating interventions in the early years of worldview development, working with young people to develop capabilities for critical thinking that strengthen their resilience to the *unknowns unknowns* of tomorrow, rather than focusing only on the current *knowns* and *knowns unknowns*.

Education, and project-based learning in particular, are intended to prepare young people for the complexities facing them as citizens in a global community (Torp & Sage 1998). At the primary and secondary school levels, the formal education system remains the most effective way of enacting change, by transmitting social and cultural values (Slaughter 2002). At the higher education level, there's an increased call for preparing 'Earth-literate leaders' (Martin and Jucker 2005), amidst an education system that remains oriented around teacher-centred pedagogy (Souleles 2017). This approach is not conducive to the development of a variety of skills that will be key in tackling the challenges outlined above, such as divergent thinking, creative problem solving, empathy, and self-reflection.

This research explores how sustainability pedagogy can be transformed through futures and design methods that encourage experiential learning. It tests the use of alternative futures as a method for experiential learning and tests whether it encourages self-reflective practices. The paper describes a study based on the design of a week long Global Summer School at Imperial College London in August 2017. It builds on previous research into the role of alternative futures as a design method in enabling systemic sustainability transitions (Angheloiu, Chaudhuri & Sheldrick 2017). The research is rooted in the fields of design education, sustainability education and futures.

2. Background

Time is of the essence if we are to enable new generations of leaders, practitioners and academics to be equipped with the skills and capabilities needed to tackle sustainability challenges (Sterling 2001). Changing sustainability pedagogy requires a new approaches. In the Western educational paradigm, a modernist view is still prevalent - focusing on mimetic learning through which students develop tacit knowledge rather than analytical thinking skills (Sterling 2001, Souleles 2017). Learning from design pedagogy can inform this much needed transformation, while the field of futures studies offers methods for prospective thinking which can help people shape their present and future actions (Dator 2002).

2.1 Design Pedagogy

This research is situated within the context that we live in a world where everyone uses design as a tool to evolve our existence, especially so as we live in an era where society is in a constant state of transition (Manzini & Coad 2015). The skillset and mindset of design is therefore equally essential for design practitioners and conscientious citizens that aim to improve their lifestyle. Since the 1980s, design education has evolved to be exemplary of thinking and learning processes which enable future practitioners to deal with complex problems and uncertainty (Lawson 1980). This has led to the development of design thinking as a field in itself and the advent of 'designerly ways of knowing' (Cross 1982). Cognitive psychologists have argued that this represents the interplay between binary processes of convergent aspects (which asks 'what comes next in this logical sequence?') of rational, deductive thinking and divergent aspects (which asks 'what might this mean?') of intuitive, open-ended thinking (Lawson 1980).

The formal education system is derived from rational ways of knowing, and it is now becoming clear that our current societal needs require far more designerly ways of knowing. This interpretation of design thinking lends itself to sustainability educators' call for 'the necessary transformation of higher education towards the integrative and more whole state implied by a systemic view of sustainability in education and society' (Sterling 2004). Tools to develop these skills are few and far between outside design-led higher education and less self-guided when offered at the secondary education levels. This is a clear area of opportunity for design education to build a more integrative capacity in all students, and especially so those from STEM background traditionally presented as linear and rational modes of study (Thompson-Whiteside et al. 2015).

Buchanan (1992) defines design thinking as problem-solving that begins as universal in scope and can apply to any area of the human experience. Futures Studies encourage pushing even further and thinking beyond today's economic and social paradigms and at every level of our society. These two approaches together enable a systemic approach that is needed in order to tackle wicked problems, such as climate change or the widening gap between the rich and the poor.

The real potential of design thinking lies in its' practical application as a project-based constructivist methodology. Design thinking becomes a tool for teachers and learners to develop the skills and competencies necessary for responding to the unknown challenges of the 21st century. Integrated into all stages, design thinking has the potential to effect a paradigm shift in education (Noweski et al. 2012), and consequently our ability to improve our personal and societal conditions.

2.2. Futures Studies

In the last decade, there has been increasing interest in the intersection of design research and futures studies. Futures studies have provided a framework for design to speculate about possible and preferable alternative futures (Dator 2009), while speculative design, as pioneered by Dunne and Raby (2001, 2014) develops multimedia fictional narratives about the present or past to provoke critical dialogue about the present. These approaches are now common within design institutions, however the resulting artifacts are in effect fine art, intended for exhibition in museums and galleries. This has triggered a response of design fictions that are ‘part story, part material, part idea-articulating prop, part functional software’ (Bleecker 2009). These objects paint a more attainable picture of a future world, though they are not typically made with any intention of being realised.

In contrast, futures and foresight methods have long been used in business and policy-making. However, the use of foresight methods in these regimes usually falls within two categories: as a prototyping method for product-service-experience innovation explorations, or as a strategy development method. The use of foresight methods in order to develop a prospective and systemic understanding of transitions for sustainability is a new area of exploration (Grin, Rotmans & Schot 2010), building on top of significant work since the second World War.

The futures methods, as used in business, have been critiqued as creating an uninspiring ‘flatland’ of futures (Slaughter 2004). Design brings much needed richness to the speculative and visionary nature of futures, and experiential scenarios expand on this through performative storytelling and diegetic props (Candy 2010). Much like the field of design, futurology is often portrayed as an expertise exclusive to experts, while in fact the participatory approach is a core value for both professions. Challenging the misconception that ‘professional experts’ are the only ones who can tackle long-term and large-scale problems, new tools are emerging to popularize and lower the barrier to entry to both design (Manzini & Coad 2015) and futures methods (Montgomery & Woebken 2016). Scenarios are one tool commonly used to help expand our ‘possibility space’ by encouraging speculation of multiple and widely varied alternative futures (Miller 2006).

2.3. Scenarios for sustainable lifestyles in 2050

The ‘SPREAD Sustainable Lifestyles 2050’ (www.sustainable-lifestyles.eu) assume a ‘sustainable lifestyle’ is defined through a material footprint of 8,000 kg per annum per person, reduced from an average of 40,000 kg today (Leppänen et al. 2013). They describe four diverse future societies and the individual lifestyles that enable meeting the target footprint. The scenarios are of the transformation type (Börjeson et al. 2006), whereby the desired target cannot be achieved without a break in the current trends and patterns.

The development process of the SPREAD 2050 used backcasting and Delphi methods in order to develop four scenarios (Singular Super Champions, Local Loops, Governing the Commons and Empathetic Communities) oriented around technological development (pandemic vs. endemic) and society’s governing principle (meritocratic vs. human-centric).

The SPREAD 2050 scenarios have consequently been augmented as part of the EU-InnovatE project (<http://eu-innovate.com>), in order to further explore the different short and long term roles of individuals, collectives and institutions in enabling sustainable lifestyles across Europe. As part of the augmentation process the EU-InnovatE project engaged over 250 non-expert participants in testing, applying and further developing the scenarios. During the augmentation process, the scenario axis

were reframed around two emerging key uncertainty axes: governing paradigm (top-down vs. bottom-up) and place-based identity (local vs. global) (Adams, Angheloiu & Armstrong 2016).

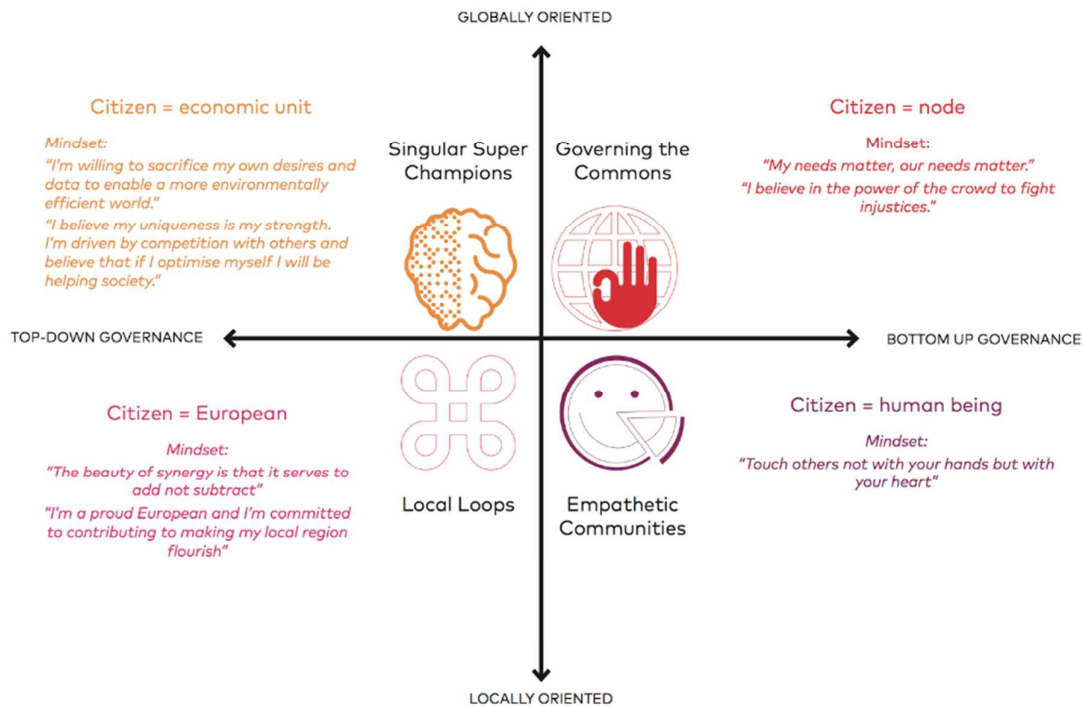


Figure 1. The augmented EU-InnovatE scenario axes and dominant mindset.

Therefore, the augmented SPREAD 2050 scenarios provided an ideal launchpad for this research as they included rigorous quantitative analysis, originally developed through the homonymous EU-funded project between 2011 - 2012 and were enhanced by qualitative insights through the EU-InnovatE project between 2013 - 2015 (Leppänen et al. 2013).

3. Design and discussion of the study

In order to develop core skills needed in tackling our present societal challenges, future generations require new methods that cultivate a capacity for speculation and critical thinking. This study aims to do this by bringing together design methods such as speculative design and foresight methods such as scenario explorations in order to cultivate prospective thinking that can hold multiple alternative lenses, or future worlds. A series of preliminary workshops designed and facilitated by the authors (Angheloiu, Chaudhuri & Sheldrick 2017) suggest an opportunity for extended research in the role of design methods for creating future imaginaries (Patomäki & Steger 2010) and backcasting present actions.

3.1 Overview of research design

The research has been conducted as part of a teaching module for the Global Summer School (GSS) at Imperial College London. Two hundred secondary school students from all over the globe attend six different tracks, out of which forty-three students joined the 'Future Envisioning' track. The brief

1
2 for 'Future Envisioning' was to develop a glimpse into life in 2050 and visualise this through designing
3 a set of future interactions and touchpoints with a particular product, service, experience or system.
4 To aid this process, we used the SPREAD 2050 Sustainable Lifestyles Scenarios, as augmented
5 through the EU Innovate project (Adams, Angheloiu & Armstrong 2016).
6

7 Narrative inquiry, performative inquiry, and visual arts inquiry were used to investigate the
8 participants' perceptions and attitudes towards the futures defined by the scenarios (Connelly &
9 Clandinin 1990).
10

11 The week long design sprint was divided into two halves to encourage divergent thinking using
12 futures methods and convergent thinking using design. The first half began with a narrative exercise:
13

- 14 ● Writing narrative prose in order to imagine a positive future in 2050 and describe the path;
- 15 ● Interrogating who has power in each participant generated story;
- 16 ● Classifying governance regimes and decision-making parties;
- 17 ● Illustrating and abstracting the narrative through emoji summaries.

18 Following this future storytelling exercise, the participants were guided through the co-creation of
19 several futures methods designed to encourage divergent thinking:
20

- 21 ● Generation Chain (Slaughter 1991);
- 22 ● Cultural Values (Schwartz 1992);
- 23 ● Introduction to futures methods and terminology;
- 24 ● Discussion and development of signals of change and trends.

25 Finally, the participants were divided into four scenarios which were used as lenses to explore:
26

- 27 ● Understanding scenario axes and developing glimpses into the future;
- 28 ● Enacting glimpses through improvisational sketches;
- 29 ● Further developing glimpses into design bodystorming (physicalized brainstorming).

30 In the second half of the sprint, participant groups were assigned a single scenario to aid their design
31 development. This phase included:
32

- 33 ● Ideation;
- 34 ● Concept Development;
- 35 ● Rapid Prototyping;
- 36 ● Design through Making.

37 The diagram below depicts the participants' learning journey:
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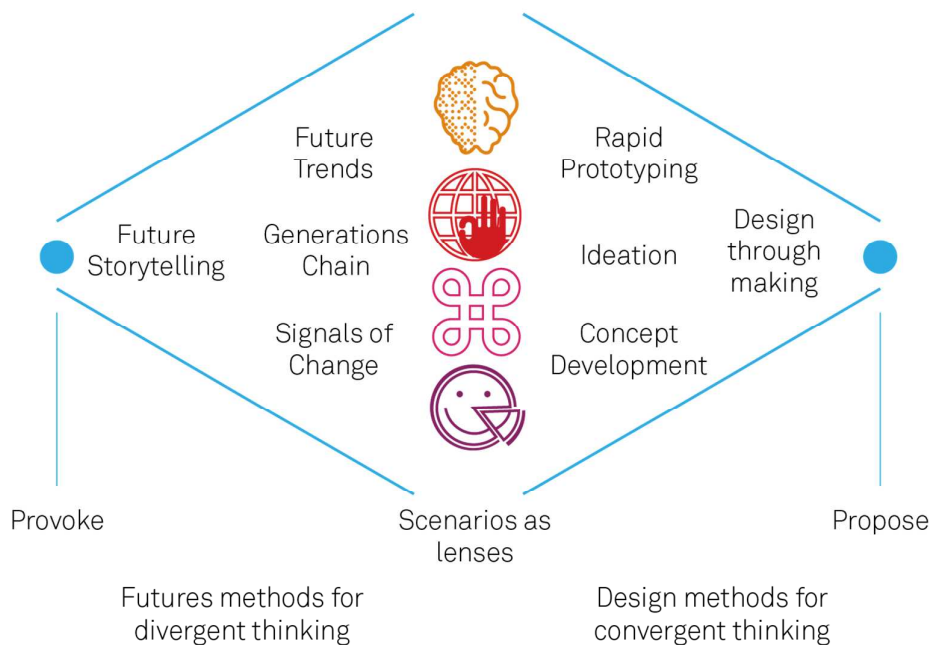


Fig. 2. Methods used to diverge and converge thinking and doing throughout the week long sprint.

The design sprint ended with a panel presentation, where the four teams presented their outputs to guest critics from both academia and practice.

3.2 Future Visions and Storytelling

1. Generations Chain

The Generations Chain is a futures method which argues that 'in order to obtain a grasp of our own context in time, we require a notion of the present which recognises that we are: 1. rooted in the past, 2. responsible for creating our near-term futures, and 3. also responsible for protecting future generations' (Slaughter 1991, 16). This argument has been popularized through the definition of sustainability still widely used today, as 'development that meets the needs of the present without compromising the ability of future generations' (Brundtland et al. 1987).

Reflecting on long-term processes of societal change can be an overwhelming task. However, the Generations Chain takes a personal viewpoint to developing a narrative arc across a family. Given the geographic spread of the participants to the GSS (predominantly from EMEA and APAC regions), this exercise allowed participants to share their stories and create a common frame of reference.

The table below depicts the hopes, fears, and major events experienced by five generations, including the participants own generation. The historical lens provided a rich source of inspiration while, perhaps unsurprisingly, future generations proved more difficult to speculate. As you can see in the table below, recurring hopes across the generations chains depict at a basic level the need for belonging and safety - with patterns around stable families, peace, the fulfillment of basic needs (food, water, housing, education) and societal 'safety'. It's worth noting here that the participants that selected for this international academic programme were of a homogenous upper socio-economic class. This revealed itself through their parents and grandparents aspirations for education and upwards mobility, and would inevitably indicate different patterns if replicated with a different participant demographic.

The grandparents' generation is marked by experiences around the aftermath of WW2 or the Cold War. Their hopes were as a result more foundational, including basic needs, peace, and building a family. Meanwhile, the parents' generation has been marked by the formation of the EU, globalisation, wars in the Arab world and the internet. The participants reflections on their parents were considerably more specific, personal, and nuanced. For many of the participants, who are first generation or second generation immigrants, their parents' lives were defined by aspirations of studying abroad, going to university, and supporting their children's education. Similarly, many shared aspirations of becoming more cosmopolitan, by travelling, living abroad, and meeting international people. While there were some themes of starting a business or having a good job, there was equal emphasis on leisure: enjoying good food, music, and holidays. One participant mentioned jetpacks and vacations on the moon -- an age-old symbol of futuristic leisure. Interestingly, their reflections on their parents' fears were much more generic and broad, including recurring themes of political instability, economic crisis, and the Cold War.

With regards to the participants' own generation, unsurprisingly, this exercise came most naturally to participants and responses had the most depth and personal meaning. One participant offered her hope to become the first female engineer in her family, sparking a lively debate over whether or not gender equality had been 'achieved' and to what degree in varying parts of the world. Other hopes reflected recent political debates including the editing of human genomes, thermonuclear energy, and decriminalizing cannabis. There were also many personal desires, including falling in love, having a family, and 'making the world a better place.' In terms of fears and major events, the key themes and markers were climate change, social media and rapid technological change. Fears touched on pollution, overpopulation, and deforestation as well as lack of jobs, rising inequality, and later retirement age. Major events covered the last ten years (for this age cohort, practically their living memory) and were non-speculative in nature.

Projected into the future, the acceleration of technological change is seen as key, with accompanying hopes and fears related to it. In terms of fears, participants strongly envision collapse-related markers for their children's generation ('WWIII, nuclear holocaust, machines taking over'), many of which share similarities to the fears experienced by their parents and grandparents generations. In terms of hopes, there was a unifying trend towards universalism for their grandchildren's generation ('world language, world currency, people on Mars'). Generally speaking the participants struggled to imagine anything beyond their own children, and even if they would actually have children themselves. As 16-17 year olds, their speculative window extended up to their next life stage: attending university.

The use of the Generations Chain as an opening exercise to the week has enabled participants to reflect on the scale and time required for societal change to happen and created the space for an upfront conversation about preferred, possible and probable futures.

Throughout the week long sprint we have used the crowdsourced hopes, fears and major events as key trends which might happen along the different scenarios pathways and used them as a way to reflect on how we might have gotten to those scenarios by 2050.

Table. 1 Generations matrix from participants perspective.

	Grandparents	arents	You	Children	Grandchildren
Hopes	Peace Building a family	Studying Abroad Going to university	Edited human genome Thermonuclear energy	Less biased and superficial society	Nanotechnologies Ingestible robots

	Food, water, clothes Education Serving the country (war) Survival Buying property	Education Living outside rural hometown Access to technology Enjoying life and music Going to university abroad Have a family Travel around the world Starting a business Supporting kids education Good careers Mingling with international people Jetpacks and vacations on the moon Higher education through grad school	Travel the world Have a family Make the world a better place Safety No pollution Less conflicts More technology Experience the world Higher education through grad school Fall in love Be the first female engineer in my family Equality Higher education Work in AI Peace Stable government Cannabis decriminalization	Competitiveness in jobs, education, social Victory over poverty Travel to other planets Provide my children with what I was able to get Better environment Enough food for everyone Clean water Not to be consumed by technology Equality People focused on helping others, not themselves A safer world Jetpacks and vacations on the moon	Cancer treatment People on Mars
Fears	Political instability Nuclear War Famine WWII Losing freedom Planes with bombs Food Shortages Mutually assured destruction Children dying Economic ruin	Economic Crisis International Conflicts Terrorism Nuclear War US / Soviet Missiles Starvation The Russians	US / Korea Tension Middle Eastern Instability Election of Trump Lack of privacy Not getting into uni nuclear warfare Terror hacks WW3 Lack of jobs Inequality Climate change Addiction to social media Later retirement age Deforestation Overpopulation Android apocalypse Totalitarian states Epidemics AI	Development of automatic driving WW3 Big Brother society Nuclear holocaust AI Hunger Overpopulation Unemployment Man-made infections Climate change	Machines uprising Hunger Overpopulation WW3 Antibiotic resistant infections Nuclear war Climate change AI
Major events	Japanese role in Korea WWII Space Age Greek Civil War Liberation from Japan China becomes a communist country Trinidad is freed from Britain Lebanon Israel War Cold War Foundation of the Turkish Republic Ottoman occupation Spanish Civil War Food Shortages Rationing Fleeing from IRA Golden Years of Lebanon Partition	Technological Revolution Cultural Revolution Wars in the Arab world Oil Shock Millennium Bug Disco Independence from Britain Globalization Nuclear technologies Communism in Egypt The Change from an LEDC to MEDC Internet End of communism Computers End of USSR Rise of capitalism The Troubles	Access to global opportunities Huge advances in computing Trump Arab Spring Smart phones Thailand coup d'etat Diamond Jubilee Epidemics like Ebola and Swine Flu Solid State Storage Greek Economic Crisis Memes Social media Refugee Crisis Economic Crisis Pop Music Biotech Start of Syrian War	Putin dies No more corruption Selfie ban AI Second space age: Mars and private space exploration Victory over diseases Machinery replacing people Everyone is equal Education for everyone New ways of human interaction	Food production efficiency Space travel for leisure AI No more religions Scientific competition World language World currency Settlements in the solar system Cure for cancer and other diseases Uninhabitable places on Earth

	China Japan War British and French rule of Egypt Revolution in Zanzibar Information Age (Telephone) Egyptian War	Punk music and rebellion Policy reform Computer related jobs Beatles Hong Kong reunification Lebanese War Decolonisation of Africa The EU	Crimea Internet Technological revolution SARS virus Religious conflict Macbook iPhone		
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The Generation Chain was followed by a reflective session which was underpinned by a discussion about values (Schwartz 1992) and the role they play in shaping our imaginaries of the future. This process enabled the participants to reflect on aspects concerning path-dependency and the events and innovations as pre-conditions that would need to be true in order for their thoughts about future generations to be possible.

2. Storytelling 2050

Following from the Generations Chain, we asked each participant to write a story about a positive view of the future in 2050 and describe how we got there, as well as how they would describe the story through emojis.

The stories highlight different beliefs about how change can happen, who are the stakeholders who have agency and the ability to influence change. They also highlight the innate capacity to tell future stories and describe pathways to get there, as all participants submitted thoughtful and in depth passages. The forty-three stories map onto the Four Generic Futures (Dator 2009). Of the stories, ten map onto 'discipline', twenty-two onto 'transform', seven onto 'grow' and four onto 'collapse'. Out of these scenarios, six imagine a multi-planetary society by 2050. Given the science and engineering focus of the cohort, it was unsurprising to find recurring patterns that depict a techno-centric 'transform' pathway as key to solving climate change and evolving human cognitive capacity.

Table. 2. Storytelling 2050 examples mapped onto Four Generic Futures and augmented EU-InnovatE scenarios.

Scenario archetype	Story	Who has power and who has not?
Grow / Singular Super Champions	I imagine there will be quicker methods of transport and older methods will be replaced. By 2050, I believe that research will have gotten to a point where we will have found a room temperature superconductor and will be in the process of using more maglev trains. I also believe, we will reach a point where a majority of cars will be self driven and automated. In terms of healthcare, I think that surgery will become more robotic (i.e. Surgeons will not operate, but rather control technology that does so for them) which will help to minimise error and maximise success rates. Lastly, I think that by 2050, we will have come up with an idea to dramatically slow down climate change and factors such as the greenhouse effect to make the world more sustainable.	The same as now.
Collapse / Empathetic Communities	Sometime between now and then, WW3 breaks out and the world falls into utter chaos. No one uses nuclear weapons though because they do not want to get hit by a nuclear bomb. Millions, perhaps even a billion people are lost. After a decade of fighting, humans find peace from the hell that they created. Unfortunately, life during the after mass is hard, but people finally understand how important Earth is and how we must be able to sustain our life on it. Humanity would learn to live to help other.	At the end, the people have equal right because after the war, everyone just wants peace.

<p>Transform / Governing the Commons</p>	<p>The world has finally achieved sustainability through symbiosis with the natural world. Through the use of our own bodies along with other flora and fauna we have achieved homeostasis managing to maintain a degree change of only 1 degree celsius. We are well on our way to reverse even that temperature change and thanks to the discovery of cold-fusion we have relegated fossil fuels to the past. By directly modifying the gas composition of our atmosphere we are slowly improving the state of the ozone layer while maintaining a relatively similar lifestyle to that of today. Despite war being a cornerstone of human history, through the creation of weapons of nearly god-like power we have effectively rendered it extinct through the threat of mutually assured destruction. As global population keeps to increase we have begun to populate other planets in our solar system to accommodate the ever longer-living human race who has achieved, thanks to science, an average life expectancy close to the biological maximum of 107 years. Thanks to our exploration and colonization of other planets we can no longer be annihilated by a single catastrophe such as an asteroid, thus ensuring our survival for millennia to come.</p>	<p>The power of government is very restricted, everyone has maximum personal and economic freedom, having power of their own lives.</p>
<p>Discipline / Local Loops</p>	<p>All major cities around the globe are sustainably powered using renewable energies like solar and wind. This is thanks to new UN restrictions on use of nonrenewable energies like petrol, as well as on permissible greenhouse gas emission levels. Cars are highly efficient and electrically powered, and also incorporate anti-collision software that has drastically reduced motor accidents worldwide. These innovations were developed by independent companies and research groups with the support of government and public funding. Plants that have been developed for high yield in harsh climates like deserts and tundra mean that food production is sufficient to sustain the growing global population, even in poor rural communities. New low-cost filtration techniques for clean water mean that a far greater percentage of people have access to potable water.</p>	<p>Active public groups have power to make informed changes. Decisions are made based on public votes, and decided on by elected officials.</p>

3. Prototyping in the 2050 scenarios

Following an introduction to the common methods and terms of reference (such as trends, signals of change and horizon scanning), the authors used incasting, or deductive forecasting (Dator 2002) to challenge the participants to develop the features of the scenarios based on top-level information. The participants were facilitated through an improvisation exercise, whereby small teams enacted a glimpse of what it would be like to be alive in the four different scenarios in 2050, based on a limited set of scenario information (the axes, mindset and headlines).

The teams enacted the glimpses they developed, and following a round of reflection, they then received a set of visual cues describing the different pathways to 2050, as well as the state of the world in each of the scenarios.

This information was used as springboard for the design process which followed standard design thinking stages such as brainstorming, ideation, concept creation and prototyping. The method explicitly enabled participants to explore the types of innovation needed to move towards a sustainable society by exploring the different pathways to 2050, as well as the scenarios themselves.

The participants formed eight groups (two for each of the scenarios) and were asked to create the following outputs:

1. An artefact / experience from the future
2. A video interaction sketch

Table 3. Outputs from the eight groups across the scenarios.

Scenario archetype	Artefact / experience from the future	Impacts and implications
Grow / Singular Super Champions	<p>Genetic School In a highly corporate future, the educational model will be designed to enable people to play to their genetical strengths and tailor genetic predispositions to influence career choice.</p> <p>SUBS The Subscription-Based Economy (SUBS) speculates about future Brain Computer Interactions, and argues for an efficiency based model for running the economy.</p>	<p>Genetic School presents a vision of a hyper efficient society assumes trends such as body augmentation and genetic engineering which may further accelerate social inequality (rather than alleviate).</p> <p>SUBS portrays a future in which market rules have led to efficiency increases across supply chains assuming the maturing of the circular economy. However, this does not mitigate social impacts such as inequality, mental health issues or knock on effects on the future of work.</p>
Collapse / Empathetic Communities	<p>RAAD In this 2050 world, energy is used as currency as a consequence of a partial collapse of society, which has led to changes in how people live - in smaller, decentralised communities. Energy transfers take place through wearable devices and enable transactions to happen.</p> <p>Self-medicating healthcare The way in which healthcare is seen has changed in society. There's ubiquitous access to knowledge and an array of body sensors monitor key health indicators. Empathy is built through lifestyle nudges to keep active with others in your community.</p>	<p>RAAD speculates that future collapse might lead to a complete reevaluation of what is perceived as valuable in society; the focus of value shifts towards 'energy' as the new dominant currency and results in innovation at the level of societal paradigm.</p> <p>Self-medicating healthcare speculates that the future of healthcare in a post-collapse world will be much more self- and community-reliant, enabled by low tech and low cost monitoring sensors.</p>
Transform / Governing the Commons	<p>Be like Mike Solar roadways retrofit helps reduce the footprint of the mobility system, assumes starting in Dubai city.</p> <p>Simplify A real-life simulator that models potential implications and impacts of actions and purchases to suggest consequences and inform people's decision-making.</p>	<p>Be Like Mike depicts the huge impact retrofitting could have in curbing climate change effects through transforming the mobility system towards a post-fossil fuel era.</p> <p>Simplify speculates that making ethical consumerism transparent and easy to navigate will enable people to make better and socio-environmentally conscious decisions.</p>
Discipline / Local Loops	<p>City Web Vertical and horizontal mass transit system in ultra-high rise cities of the future leads to heightened efficiency of transport and makes better use of current road surfaces and land taken up by roads.</p> <p>Hive Hives are smart homes linked together around central social hubs. Local energy production is stored in in built batteries and local trading schemes encourage people to be good neighbours while keeping their environmental footprint down.</p>	<p>City Web portrays how the rapid densification of cities has required top-down interventions to make the mobility system as efficient as it could be, with the potential to redevelop ground level space currently dedicated to roads and parking into urban farms and other community uses.</p> <p>Hive presents a vision of energy-independent, networked housing districts depicts a future in which the energy grid is transformed and is integrated with other urban systems</p>

		such as housing development.
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Seven out of the eight concepts assumed a highly techno-centric future as given, which speaks to the dominant view which emerged from the storytelling exercise as the archetypal 'transform' future. In comparison, previous research conducted by the authors with postgraduate students using the same scenarios as a basis for concept development, all groups speculated a 'collapse' event triggering societal change (Angheloiu, Chaudhuri, Sheldrick, 2017). This further highlights generational differences between 'millennials' and 'Gen Z', as well as the impact of socio-economic status in influencing outlook and aspirations for the future

3.3. Implications for sustainability pedagogy

This summer school was an exploration of a pivotal point in a young person's learning journey, a stage defined by university applications and corresponding career choices. The summer school format allowed for project-based learning atypical in the formal learning environment, as a first step towards cultivating 'Earth-literate leaders'.

As one student reflected, 'This is a science summer school, but the future visions topic got us to think more about the social impact of science.' The process of design as an intervention and not as content learning enabled practically oriented students (future scientists) to consider the future glimpses they developed as touchpoints with potentially broader-reaching impact. A shift in mindset is key to unlocking behaviours and attitudes that can enable future practitioners to be geared towards enabling sustainable lifestyles (Meadows 1999). In turn, the assumption that mindset change can be seen both as ends and means to unlock wider cultural shifts needed for sustainability would need further testing.

The dominance of the 'transform' outlook as a preferred pathway to reaching a sustainable future would need further testing across different socio-economic and age groups, to establish whether it marks a generational shift between millennials and Gen Z, as well as across a more diverse range of socio-economic backgrounds. With the exception of one group (RAAD), participants struggled most throughout the process with the bottom-up and local scenarios. Despite reflecting on the much more localized nature of their grandparents' and parents' lifestyles, participants found changes in the dominant globalized nature of our current world highly counterintuitive. This further reinforces the pervasiveness of 'transform' as a preferred pathway. Anecdotally, many participants struggled with a perception that the only viable paths suggested a departure from individualistic paradigms (linked to capitalism) towards communitarian pasts that their own forefathers had transitioned away from.

Scenarios play two key functions: firstly they encourage systemic speculation across a widely varied set of alternative futures, and secondly, they enable reflective approaches on the nature, pace and characteristics of radical long-term change.

The assumption of a drastically changed future society enabled the students to think of change as a pathway, not unlike the lived histories of their own parents, grandparents, and ancestors. The students were able to critically interrogate the social, political, and ethical infrastructure necessary in order for their technological innovations to effect change.

4. Conclusions

The method builds on significant prior work in futures studies, systems thinking, and critical design. The unique contribution lies in the application of futures and design thinking methods in the design of sustainability learning experiences for secondary school students. The results suggest the potential for more experiential learning to explore possible futures and enable students to reflect and test their dominant assumptions around the role and applications of technology in achieving and maintaining sustainable societies over the next few decades.

This presents an opportunity for more immersive methods for experiencing scenarios and different pathways, which could aid in the suspension of disbelief of participants working with scenarios which might not follow the intrinsic assumptions they hold about the future. The learning experience also illustrated the necessity of integrating politics, economics, and ethical frameworks into traditionally siloed STEM subjects and more generally into the conceptual stages of any design project.

References

1. Crutzen, Paul J. 2006. 'The "Anthropocene"'. In *Earth System Science in the Anthropocene*, 13–18. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-26590-2_3.
2. Grin, John, Jan Rotmans, and Johan Schot. 2010. *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. Routledge.
3. Meadows, Donella H. 1999. *Leverage Points: Places to Intervene in a System*. Sustainability Institute Hartland, VT. http://leadership-for-change.southernafricatrust.org/downloads/session_2_module_2/Leverage-Points-Places-to-Intervene-in-a-System.pdf.
4. Elkington, John. 2002. Enter the triple bottom line. *The triple bottom line: Does it all add up*, 11(12), 1-16.
5. Charter, Martin, and Ursula Tischner. 2001. *Sustainable Solutions: Developing Products and Services for the Future*. Greenleaf Publishing.
6. Ehrenfeld, John. 2008. *Sustainability by Design: A Subversive Strategy for Transforming Our Consumer Culture*. Yale University Press.
7. Beddington, John. 2010. "Food security: contributions from science to a new and greener revolution." *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 365
8. Torp, Linda, and Sara Sage. *Problems as possibilities: Problem-based learning for K-12 education*. ASCD, 1998.
9. Martin, Stephen, and Rolf Jucker. 2005. 'Educating Earth-Literate Leaders'. *Journal of Geography in Higher Education* 29 (1):19–29. <https://doi.org/10.1080/03098260500030298>.
10. Slaughter, Richard A. 2002. *New Thinking for a New Millennium: The Knowledge Base of Futures Studies*. Routledge.
11. Souleles, Nicos. 2017. 'Design for Social Change and Design Education: Social Challenges versus Teacher-Centred Pedagogies'. *The Design Journal* 20 (sup1):S927–36. <https://doi.org/10.1080/14606925.2017.1353037>.
12. Angheloiu, Corina, Goldie Chaudhuri, and Leila Sheldrick. 2017. "Future Tense: Alternative Futures as a Design Method for Sustainability Transitions." *The Design Journal* 20 (sup1):S3213–25. <https://doi.org/10.1080/14606925.2017.1352827>.
13. Dator, Jim. 2002. *Advancing Futures: Futures Studies in Higher Education*. Greenwood Publishing Group.
14. Manzini, Ezio, and Rachel Coad. 2015. *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. Cambridge, Massachusetts: MIT Press.
15. Lawson, Bryan. 2005. *How Designers Think: The Design Process Demystified*. 4 edition. Amsterdam: Routledge.
16. Cross, Nigel. "Designerly ways of knowing." *Design studies* 3, no. 4 (1982): 221-227.
17. Sterling, Stephen. 2001. *Sustainable Education: Re-Visioning Learning and Change*. Schumacher Briefings. Schumacher UK, CREATE Environment Centre, Seaton Road, Bristol, BS1 6XN, England.
18. Thompson-Whiteside, Scott, Gavin Melles, Neil Anderson, and Tom Barrett. 2015. 'Problem Finding through Design Thinking in Education'. In *Inquiry-Based Learning for Multidisciplinary Programs: A Conceptual and Practical Resource for Educators*, 3:191–209. *Innovations in Higher Education Teaching and Learning* 3. Emerald Group Publishing Limited. <https://doi.org/10.1108/S2055-364120150000003027>.

19. Buchanan, Richard. 1992. 'Wicked Problems in Design Thinking'. *Design Issues* 8 (2):5–21.
20. Noweski, Christine, Andrea Scheer, Nadja Büttner, Julia von Thienen, Johannes Erdmann, and Christoph Meinel. 2012. 'Towards a Paradigm Shift in Education Practice: Developing Twenty-First Century Skills with Design Thinking'. In *Design Thinking Research*, 71–94. Understanding Innovation. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-31991-4_5.
21. Dator, Jim. 2009. Alternative futures at the Manoa School. *Journal of Futures Studies*, 14(2), 1–18.
22. Dunne, Anthony, and Fiona Raby. 2014. *Speculative Everything: Design, Fiction, and Social Dreaming*. Cambridge, Massachusetts ; London: MIT Press.
23. Dunne, Anthony, and Fiona Raby. 2001. *Design Noir: The Secret Life of Electronic Objects*. Springer Science & Business Media.
24. Bleecker, Julian. 2009. 'Design Fiction: A Short Essay on Design, Science, Fact and Fiction – Near Future Laboratory'. Near Future Laboratory (blog). 2009. <http://blog.nearfuturelaboratory.com/2009/03/17/design-fiction-a-short-essay-on-design-science-fact-and-fiction/>.
25. Slaughter, Richard. 2004. Transcending 'flatland'. In *Futures beyond dystopia: Creating social foresight*. London: RoutledgeFalmer.
26. Candy, Stuart. 2010. 'The Futures of Everyday Life: Politics and the Design of Experiential Scenarios'. University of Hawaii at Manoa. <http://www.benlandau.com/wp-content/uploads/2015/06/Candy-2010-The-Futures-of-Everyday-Life.pdf>.
27. Montgomery, Elliot, and Chris Woebken. 2016. *Extrapolation Factory - Operator's Manual: Publication version 1.0*. CreateSpace Independent Publishing Platform, United States.
28. Miller, Riel. 2006. Futures studies, scenarios, and the "possibility-space" approach. *Schooling for Tomorrow* 58.
29. Leppänen, Juha, Alekski Neuvonen, Maria Ritola, Inka Ahola, Sini Hirvonen, Mika Hyötyläinen, Tuuli Kaskinen, Tommi Kauppinen, Outi Kuittinen, Kaisa Kärki, Michael Lettenmeier and Roope Mokka. 2013. *Scenarios for Sustainable Lifestyles 2050: From Global Champions to Local Loops*. Retrieved from UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production (CSCP): http://www.sustainable-lifestyles.eu/fileadmin/images/content/D4.1_FourFutureScenarios.pdf.
30. Börjeson, Lena, Mattias Höjer, Karl-Henrik Dreborg, Tomas Ekvall, and Göran Finnveden. 2006. 'Scenario Types and Techniques: Towards a User's Guide'. *Futures* 38 (7):723–39. <https://doi.org/10.1016/j.futures.2005.12.002>.
31. Adams, Gemma, Corina Angheloiu and Louise Armstrong. 2016. "Citizens Bringing the Future Forward". The Futures Centre (report).
32. Patomäki, Heikki, and Manfred B. Steger. 2010. 'Social Imaginaries and Big History: Towards a New Planetary Consciousness?' *Futures, Global Mindset Change*, 42 (10):1056–63. <https://doi.org/10.1016/j.futures.2010.08.004>.
33. Connelly, F. Michael, and D. Jean Clandinin. 1990. 'Stories of Experience and Narrative Inquiry'. *Educational Researcher* 19 (5):2–14.
34. Schwartz, Shalom. 1992. Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. *Advances in Experimental Social Psychology*, 25, 1–65.
35. Brundtland, Gro Harlem and others. 1987. 'Our Common Future: Report of the World Commission on Environment and Development'. UN Documents Gathering a Body of Global Agreements.

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