INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
8 & 9 SEPTEMBER 2016, AALBORG UNIVERSITY, DENMARK

THE DESIGNER AND THE SCIENTIST: THE ROAD TO INSPIRE TRANSDISCIPLINARY SYNERGIES

Gionata GATTO and John Richard McCARDLE
Loughborough Design School

ABSTRACT
It is essential for the contemporary design practitioner to meet the complex challenges that define modern knowledge-based economies. Within both the professional and educational context, being effective requires broad analytical skills and an adaptive attitude to learning. Developing such knowledge to include a deeper understanding of science, technology, and society, and how the interplay of these domains influences culture and politics, has become crucial.
Transdisciplinary engagement relies on the ability to draw together observations from a broader range of subject matter than currently employed in the core of most design curricula. Within a design educational context this is often assimilated through a problem-solving approach to learning, but at practitioner level it is often a far less systematic route to take. The case study presented here illustrates that Designers would benefit from learning about creative forms of practice-based participatory action as a prerequisite to engaging in transdisciplinary collaborative projects.
This paper provides an insight into funded research that entailed a designer establishing a synergistic relationship with a natural science institution. The work reports on the transdisciplinary collaboration and the interventions of design thinking within a standardized cycle of scientific enquiry that supported the pursuit of plant science research. The outcome provided artefacts for public engagement and the representation of future scenarios for botanical concepts as a way to obtain mutual benefits for the designer, the scientific partners and the social demographic audience.

Keywords: Design thinking, Speculative (Critical) Design, transdisciplinary, science, education.

1 INTRODUCTION

In the context of contemporary integrated knowledge economy [1], designers are facing a multitude of radically new challenges, in which they are expected to play progressively strategic roles [2]. Between those roles, encouraging the public debate and informing government policy through design thinking has recently become a valued feature of organizations such as the Design Council and The Policy Lab, both located in the UK. According to Ken Friedman, the current global economy indicates a departure from the previous models, giving rise to new exploratory areas, which offer unprecedented opportunities to “directly act on biological, molecular and atomic structures, involving the growing sectors of biotechnology, nanotechnology, additive manufacturing and other new fields.” [3]. The type of knowledge brought about from the designer who operates in those contexts is intrinsically multi-disciplinary as it often emerges from the synergies of interdisciplinary collaboration.
The edification of such an advanced knowledge of practice, “requires a fundamental change [also] in design education” [*ibid.*] and should involve a deep focus on society, science, technology and the understanding of how these interact with each other to finally influence culture and politics. Donald Norman asserted that, “Design schools do not train students about these complex issues, about the interlocking complexities of human and social behaviour, about the behavioural sciences, technology, and business. There is little or no training in science, the scientific method, and experimental design” [4]. From an educational perspective however, broadening the horizons of designers into the realms of science is relatively rare although clearly achievable [5].
The issues raised by Friedman and Norman are of a qualitative nature and primarily focus on the content of the educational paths proposed in most design curricula. At the same time, both authors raised a second theme, which is more concerned with the attitude of the designer at work: “how” practitioners think and design within the context of interdisciplinary environments.

2 SPECULATIVE (CRITICAL) DESIGN (SCD), SCIENCE, SOCIETY AND THE QUEST FOR IMPACT: TOWARDS A NEW MODEL OF KNOWLEDGE

While the interaction of artistic and scientific practices are not new (see SciArt [6] for example) for research cross-overs between design and science the situation is somewhat different. Design has been defined as "a normative practice" in that any action "attempts to produce new conditions or the tools by which to understand and act on current conditions" [7]. Through design, visions and ideas become transmutable and thus accessible in the present.

Over the last decade the interactions involving both the designer and the scientist at work have mainly built on scenario-based design involving narrative representation strategies to support public understanding and engagement with science and technology. Examples include the practices of Speculative Design [6], [8], [9], Speculative Visualization [10] and Critical Design [11], [12], from which has emerged ways of probing alternative socio-technological futures and their impact on society. Most of these approaches productively re-frame, order and integrate diversified expertise through the multiplicity of "synthesizing" processes of the design profession [13, p. 30].

The motivation that sees designers approaching scientists to shape socially and technologically meaningful body of works at the boundaries between the two domains is a debated subject, which has increasingly gained the attention of the creative industry [14]. One re-occurring theme concerns the modus operandi (M.O.) of practitioners working in the field: how do designers and scientists co-conduct research and particularly for what audience will both the research process and outcomes represent valuable knowledge?

Social Scientist Helga Nowotny asserts that, within the flow of information that should intervene bi-directionally between science and society, alternative forms of knowledge production need to be found. Not solely scientifically reliable forms of knowledge, but also "socially robust" kinds [15]. Nowotny defines such knowledge "Mode-2" [16] and describes it as "trans-disciplinary" to acknowledge its "trans-gressiveness" in respecting boundaries and that a mutual understanding of the other discipline's language is not only necessary but also helps identifying where the pressure for joint problem-finding and solving comes from.

Questioning practice clearly implies that future educational paths should adapt to support a generation of designers that not only knows "what design is and how science works" [17] but that is also aware of how transdisciplinary research can lead to beneficial outcomes for the multiplicity of target audiences considered during the research process.

3 THE CASE STUDY OF GEOMERCE: TURNING CROPS INTO MINERAL MINES

Geomerce [18] is a project where the natural sciences, laboratory work, financial market and technology crossed over through the synthesizing narrative of design. Geomerce started as a collaborative research project funded by Stimuleringsfonds Creatieve Industrie and conducted in partnership with International Laboratory of Plant Neurobiology, Life Sciences department of the University of Parma, Plant Sciences Group from the University of Wageningen and C-CIT, a Swiss company specialized in the production of laboratory equipment. The research structure supporting the project has been designed through practice and brought about an '*inventive*' research method [19], which was divided into four main functional areas (Figure 1) according to the research aims:

1. Observing and predicting;
2. Co-Designing the technology;
3. Cross-breeding aesthetics;
4. Projecting imaginative performances.

The first three stages were further divided into two interrelated phases, a) Analytic and b) Imaginative.

The theme behind Geomerce belongs in the domain of Natural Sciences and focuses on a phenomenon that naturally occurs in plants: that certain species absorb heavy metals from the soil using the roots. The topic was chosen during the first phase of the research (Observing & Predicting), according to the growing urgency recently highlighted by the EU to protect European soils from degradation [20].

Certain species, known as hyper-accumulators [21], are being studied for their efficiency at absorbing heavy metals such as zinc, copper and nickel from the soil and accumulating these elements into their leaves. The accumulated metals can then be extracted by harvesting the leaves and burning the biomass: a process known as "Phytomining" [21]. Since many of the accumulated heavy metals are also listed on international markets such as the London Metal Exchange (LME), the first outcomes of this research resulted in an installation (Figure 2) that re-imagines the way people think of agriculture. Fields and crops are proposed as financial assets and reservoirs of capital.

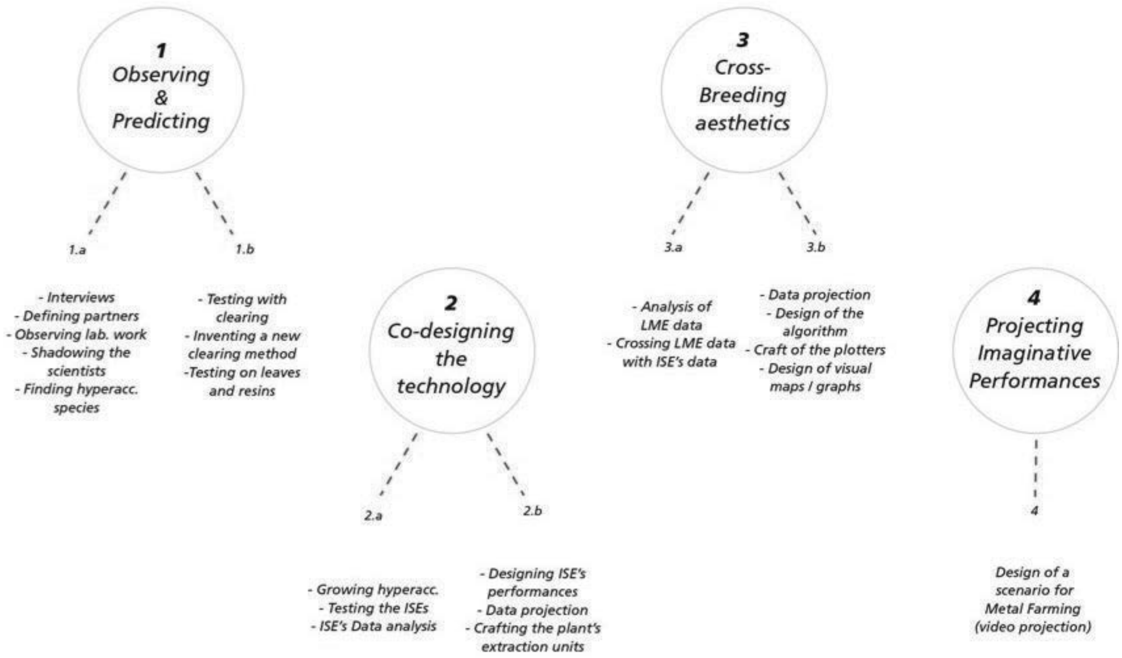

Figure 1. The inventive method used to conduct the research and design the installation

In the installation, the metal uptake of selected plants is monitored in real time through a series of bespoke Ion Selective Electrodes, and the amount accumulated is used to calculate the overall monetary value by using the real-time stock exchange rate of the commodity. As a result, the values of the plants vary constantly according to the metals' market and the plants' accumulation performance. This value is converted and represented on a circular plot via a series of polar plotters designed as part of the installation.

Figure 2. The installation setup

An animated video of a scenario in which agriculture blurs with finance, and farming decisions are made according to financial changes, was designed to help the audience to imagine possible futures of scientific research concerned with a plant's 'mining' performance.

4 DESIGN THROUGH SCIENCE AND SCIENCE THROUGH DESIGN: BRINGING HYBRID ENTITIES INTO BEING

From a scientific perspective there was, and still is, no evidence that demonstrates the real time performative activity of hyperaccumulators. Most laboratory research is currently based on methods focused on plant tissue sampling over specified time periods. Calculating real-time performance is considered a critical topic in laboratory plant research as there is a real challenge in isolating and removing specific variables. In light of the scientific opportunities deriving from the introduction of unique measuring technologies we initiated an investigation on alternative possibilities to track the activity of plants in real-time.

Despite the absence of commercially available sensors to detect the metals (Nickel, Copper, Zinc) accumulated by the selected plant species (Noccaea C., Eichornea C., Heliantuus A.), the opportunity to develop a dedicated technology that would catch the plant scientists' attention attracted the engagement of the Swiss company C-CIT into the project.

It was subsequently found that an Ion Selective Electrode (ISE) can convert the activity of a selected ion dissolved in water into electrical potential, suitably calibrated it provided a direct measure of metals accumulated. Such technology was identified as a simple yet ideal instrument, with the plant roots immersed in a metal-contaminated water solution, selected ISEs could be used to track the variations occurring in the liquid substrate of each plant at a given time interval (Figure 3).

The electrode specification was co-developed by the designers, a group composed of a Professor of Plant Genetics and a laboratory technician from the University of Wageningen, a Professor of Biotechnology from the University of Parma and finally manufactured by an engineer at C-CIT. Co-designing such deliverables required the full understanding of the extraction capacity of the plants using available scientific documentation, and subsequently speculating on how a plant would deploy such capacity over a period of time.

Despite the developed technology having not been fully evaluated, a series of performance tests was conducted in a laboratory at the University of Wageningen (NL). The experiments involved the use of the newly built ISEs to detect the presence of heavy metals dissolved in a water-based liquid. From a solution of water containing a known amount of Nickel, Zinc and Copper, measured amounts of liquid were subtracted at time intervals of 2 minutes, to check whether the ISE's sensitivity was sufficient to probe minimum abatements of metal. The time interval was decided between the designers and the scientists in relation to the narrative logic behind the installation: every two minutes the LME updates the stock value of traded metals and correlating this data with that produced from the ISE ultimately generated information to craft the scenario for the installation.

Figure 3. The sensors co-designed from the designers with Wageningen University, Parma University and produced by C-CIT

The overall adopted strategy embodied what DiSalvo has defined as "Countercollective" (DiSalvo, 2012): a device where a system of functions operates antagonistically to another system of functions.

Thus, instead of focusing on the plant itself, this research phase was conducted with a focus on its environment and the changes produced due to the plant's activity.

5 EXPERIENCE OF THE PROCESS

This research phase embodied an approach that involved designing through science, which generated periods of physical and mental pressure for the designers. It was noted that specialized expertise was continuously added to the discussion, adopting a strictly scientific terminology, an issue which is known to raise barriers between the multiple stakeholders involved in multidisciplinary collaborative projects [22]. For example, understanding the extraction performance of a plant species was one of the first issues encountered from the designer during the research process. To support this process, both a professor of the University of Life Sciences of Parma and one from the Plant Sciences group of Wageningen provided some scientific documentation. The documents consisted of publications reporting the results of experiments involving a hyperaccumulator species growing on Mt. Prinzera, a mountain naturally rich of Nickel due to the presence of ultramafic stones. Such species, that is, a peculiar phenotype of *Noccaea Caerulescens* is considered to be particularly efficient in extracting Nickel from the soil.

Furthermore, the awareness that as designers we were going to produce a technology that was rooted on a speculation heightened the risk of producing a useless technological device. To compromise the outcomes of the installation, as well as the interest of the scientific partners, presented serious challenges related to professional credibility.

Conversely, from a scientific perspective, co-designing a technology based itself on a scientific speculation represented, for the scientists involved, a real opportunity for producing scientifically robust knowledge. If the technology worked, unprecedented plant-related research paths could be explored and at the same time support the projection of new speculations for the future. Conversely it would just prove the initial assumptions to be wrong, a result that still represents a useful step within the applied sciences. This particular scenario proved to be a way to produce science through design, and involves the narrative tools of speculative representations to explore the potential of new scientific equipment, alternative protocols and data collection methods.

The dissemination of the final design, its concept, technology and hence scientific principles supporting the project was carried out by means of an exhibition installed at Fuorisalone, during the Milan Design Week [23]. Once performing and interacting with the audience of Fuorisalone, the designers believed that Geomerce demonstrated a semantic that moved beyond the speculation, the narration and the scientific fact. Indeed, as intended, it reflected the potential to shape an alternative future space where individual disciplines transgress their limits into a much more valuable resource, capable of generating new and compelling scenarios for further investigation.

6 CONCLUSIONS

Geomerce aimed to illustrate that a transdisciplinary *M.O.* involving speculative design and science could be a driver to shape a new knowledge model wherein its actors operate to strengthen the links between technology, scientific progress and society**.**

Science and design not only reciprocated to inform each other during the research process. We also argue that the scientific informed the final design. Likewise the imaginative, namely, its speculative representation and that a double informed research process rooted on scientific reliability and technological feasibility drove the possible emergence of inedited insights.

Accordingly, the aesthetic of the designed entities produced a form of a hybrid language, situated somewhere at the middle between the technicality of laboratory equipment, the narrative language of scenarios and the functional interactivity of the performative act. Designing and doing science through that combination of elements, has resulted in beneficial outcomes, regardless of their success in the respective fields of application, namely the scientific laboratory or the public exhibition. Such paths include the potential to bring into being an inclusive approach to problem-finding and solving that deserves to be further analyzed from a variety of perspectives, not least of which the one related to the topic of public expectations and engagement with science.

The design research project described in this work highlighted how a M.O. supported from the key themes of scientific reliability and technological feasibility can work as a potential facilitator to generate a hybrid form of knowledge. Echoing Helga Nowotny, we introduce the importance of stressing not only the scientifically reliable form of knowledge, but also a narratively robust one. It is argued that, in this model of knowledge production, the scientific fact, its speculative foundations and the derivation of contextual narratives are tightly linked together and can support transdisciplinary working and cross disciplinary education through the participatory design of scientists, designers and technology producers.

REFERENCES

[1] P. F. Drucker. *Post-Capitalist Society*, 1993 (HarperBusiness, New York).
[2] W. Hutton. Design in the knowledge economy 2020. *Landscape*, 2010, pp.1–8.
[3] K. Friedman. Models of Design: Envisioning a Future. *Visible Language*, 46 (1/2), pp.132–153, 2012.
[4] D. Norman. *Why Design Education Must Change*. *Jnd.org*. [Accessed on 2016, 06 January] Available: http://www.jnd.org/dn.mss/why_design_education.html.
[5] J. R. McCardle. Science Informed Design: Involving the Physical and Natural Sciences. In *Engineering & Product Design Education*. Loughborough, September 2015. pp. 2–7.
[6] A. Dunne and F. Raby. *Speculative Everything*. 2013 (MIT press, Cambridge).
[7] C. DiSalvo. *Adversarial Design*, 2012 (MIT Press, London).
[8] J. Auger. Speculative design: crafting the speculation. *Digital Creativity*, 2013, (24, 1), 11–35.
[9] C. Disalvo. Spectacles and tropes: Speculative design and contemporary food cultures. *Fibreculture Journal*, 20, 2012, pp.109–122.
[10] K. Tanyoung and C. DiSalvo. Speculative visualization: a new rhetoric for communicating public concerns. *Design Research Society*, 2010.
[11] A. Dunne. *Hertzian tales : electronic products, aesthetic experience and critical design,* 2005 (RCA CRD Research Publications, London).
[12] A. Dunne and F. Raby. *Design noir : the secret life of electronic objects*. 2001, (August/Birkhauser, London).
[13] I. Farías and A. Wilkie. *The Design Studio As A Centre Of Synthesis*, In *Studio Studies*, 2016 (Routledge, London).
[14] D. Arets. [Accessed on 2016, 22 February]. *Designers as Lapdogs for Scientists?," Ceate Out Loud, Daily Design Talkshow, MU Eindhoven*. Available: https://www.designacademy.nl/News/tabid/2055/articleType/ArticleView/articleId/2402/Designers-as-lapdogs-for-scientist.aspx.
[15] H. Nowotny. *The potential of transdisciplinarity*. In *Discussing Transdisciplinarity: Making Professions Ant the New Mode of Knowledge Production*, 2004 (Oslo School of Architecture and Design, Oslo).
[16] H. Nowotny, P. Scott and M. Gibbons. Mode 2 Revisited: The New Production of Knowledge. *Minerva*. 2003, pp. 10–19.. 41, 179–194.
[17] L. Crouch and A. Odling-Smee. *Science Needs Funding Pots for Design*. [Accessed on 2016, 26 February]. Available: http://design-science.co.uk/science-needs-funding-pots-for-design/
[18] G. Gatto. *Geomerce: Turning Crops Into Mines*. [Accessed on 2015, 20 December]. Available: https://vimeo.com/125036758.
[19] C. Lury and N. Wakeford. *Inventive Methods: The Happening of the Social*. 2012 (Routledge, Abingdon).
[20] L. Montanella. Govern our soils. *Nature*, 2015, 528, pp.32–33.
[21] R. R. Brooks, M. F. Chambers and L. J. Nicks, B. H. Robinson. Phytomining. *Trends in Plant Science*, 1998, 3(9). pp.359–362.
[22] L. O'Brien, M. Marzano, and R. M. White. Participatory interdisciplinarity: Towards the integration of disciplinary diversity with stakeholder engagement for new models of knowledge production. *Science Public Policy*, 2013, 40(1), pp. 51–61.
[23] N. Di Battista (Editor). *Geomerce*. *DOMUS*. [Accessed on 2016, 22 February] Available: http://www.domusweb.it/en/news/2015/05/22/gionata_gatto_and_giovanni_inella_geomerce.html§