

Field Theory Artistic Research in Light, Air, and Matter



Field Theory: Artistic Research in Light, Air, and Matter

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Northern Portugal Regional Coordination and Development Commission

A Smart Institution

The Northern Portugal Regional Coordination and Development Commission (CCDR-N) is a public institution whose work aims at the integrated and sustainable development of the Northern Region of Portugal, contributing to the country's competitiveness and cohesion. Tasked with implementing environmental, city and land planning and regional development policies in the Northern Region (NUTS II), CCDR-N is also responsible for promoting the coordinated actions of decentralised services at a regional level and provide technical support for local authorities and their associations. Among its various attributions, highlight goes to the management of the Alto Douro Wine Region, classified as a World Heritage Site by UNESCO. CCDR-N is also responsible for managing community programs based on funds allocated to Portugal by the European Union, as well as other financing instruments intended to promote regional development.







Faculty of Engineering, University of Porto An Institution of International Reference

With origins dating back to the 18th century, the University of Porto is one of the most prestigious Higher Education Institutions in Europe. It has close to 31.000 students, 2.061 teachers and researchers along with 1.658 administrative staff within its 15 schools and 51 scientific research units, spread across 3 university campuses located in Porto.

The Faculty of Engineering (FEUP) is the largest faculty of the University of Porto, with more than 8.600 students, 86 courses and close to 600 teachers and researchers across 9 departments of engineering: Chemical, Civil, Electrical and Computer, Industrial and Management, Informatics and Computing, Mechanical, Physics, Metallurgical and Materials, and Mining. The main Research & Innovation areas of activity are Environment Technologies, Sea Technologies, Food Technologies, Biotechnology, Health Technologies, Materials Technologies, Mechanical Engineering, Electrical Engineering, Automation and Control, Information and Telecommunication Technologies, Systems Technologies, Energy Systems and Energy, Quality and Food Safety, Risk Prevention and Reduction, Industrial Management.

FEUP is located in the Porto Innovation District, where the strong presence of engineering technologies, health sciences and entrepreneurship lend considerable impetus to the process of innovation. An example is the Science and Technology Park of the University of Porto, a fundamental structure of support to knowledge transfer between the university and the market.





Faculty of Fine Arts, University of Porto

Lúcia Almeida Matos

Since its beginning in the 18th century, the Faculty of Fine Arts of the University of Porto (FBAUP) educates and promotes knowledge in the fields of Art and Design with a clear understanding of their role in the development of scientific and technical solutions for societal needs. FBAUP's increasing participation in multidisciplinary R&D projects across the University of Porto shows the many ways in which Art and Design contribute to the design and development of processes and outputs as well as to communication within scientific communities, businesses, and society at large. Collaboration between the fields of Engineering and Art and Design within the University of Porto has been particularly valuable, yielding mutually beneficial results. With the aim of improving the quality of life and health of citizens, the 2SMART project is yet another instance of this longstanding collaboration. While Communication Design has a role across all activities of the project by developing effective communication tools, the exhibition Field Theory presents the materialization of artistic research into innovative, technology-based works of art.

Deeply rooted in its local community, FBAUP has also a long tradition of establishing international links with Art and Design schools across the world. Such dialogues and ongoing joint projects show the increasing relevance of creative areas to answer current environmental and societal challenges. However, solutions can only be found through multidisciplinary efforts and FBAUP will keep promoting productive conversations with Science and Engineering, with the ambition of expanding the positive impact of Art and Design in the lives of citizens across the globe.







2SMART

Engineered Smart Materials for Smart Citizens

Arminda Alves

The project 2SMART, engineered smart materials for smart citizens, aims to develop smart solutions of engineering and design to improve the quality of life and health of citizens. 2SMART fits in the "Climate-Neutral and Smart Cities" mission of Horizon Europe, where the "cities and metropolitan areas", as centers of economic activity, knowledge generation, innovation and new technologies, impact upon the quality of life of citizens who live and/or work in them and they are major contributors to global challenges. The project is divided in 5 main areas of expertise:

Activity 1 – Engineered smart materials for energy is intended to develop monolithic solar cells for efficiently harvesting indoor light irradiation to power the Internet of Things (IoT), electronic controls (e.g., TV and air-conditioning), and as an extension of the battery for tablets and mobile phones, among many other applications.

Activity 2 – Engineered smart materials for protection of air quality is intended to develop a smart low-cost device to reduce children's health risks from indoor air pollution exposure in schools, with scientifically calibrated and validated sensors, capable of interacting with the end-users and suggesting them the most adequate mitigation measures. Activity 3 – Engineered smart materials by digital manufacturing for environmental applications is intended to develop (photo)catalytic nanomaterials, as well as absorbent materials through novel synthesis and modification methodologies, to be used in the manufacture of structured reactors using additive manufacturing (3D printing) to control and remove greenhouse gases and other contaminants in the cities.

Activity 4 – Engineered smart materials for cancer diagnosis and therapy is intended to work on the nanoencapsulation of anticancer drugs for new therapeutic approaches to brain cancer, the development of new platforms for cancer photoimmunotherapy based on nanographene formulations and near infrared radiation, and the use of nucleic acid mimics (NAMs) as a strategy for detection and treatment of bacteria associated with cancer.

Activity 5 – Communicating science and technology with art and design is intended to link art and design-based activities to the previous targets, by: 1) developing artistic residencies that encourage the collaboration of scientific researchers and artists to spur the debate about the quality of life, the health of citizens and the inquiry on the effects of technology and science; 2) promoting design research, focusing on the communication of science, so that the outcomes of the previous targets can be made accessible and more understandable to their target audiences.

2SMART profits from the complementary competences and resources of the 4 participating research units of the University of Porto, creating synergies from fundamental to applied research, where art and innovation combine.

The Host Institution

The Faculty of Engineering of the University of Porto (FEUP) is a leading institution of international reputation in teaching and research. Located in Asprela Campus, it hosts 8 R&D centers that promote the development of innovative technological solutions. This project counts on the participation of FEUP's R&D centers — LEPABE, LSRE-LCM and CEFT — who formed a consortium to create, in 2021, the **ALICE – Associate Laboratory in Chemical Engineering** (alice.fe.up.pt), involving ca. 370 researchers. The leader of the project is LEPABE.

The Research Centers

LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy, created in 1998 as an interdisciplinary group, is mainly located at the Chemical Engineering Department. Consistently classified as "Excellent" by international evaluation panels appointed by FCT, it has been growing over the years. LEPABE's mission is to develop innovative processes and products to respond effectively to societal challenges, using the basis of chemical and biological engineering to improve quality of life in a sustainable and safe way. Its goals are in line with the Horizon Europe common strategic priorities, focusing on research excellence, industrial competitiveness and societal challenges. LEPABE's research is based on 3 pillars of development: Sustainability and Energy, Processes and Products, Environment and Health. Our scientists are stimulated to cooperate with colleagues from different research fields, increasing synergies and seeking advances in cross-cutting areas. The organization in research groups, their strategic objectives and laboratory conditions are available at lepabe.fe.up.pt. LEPABE is the coordinator of this project and major areas of competence include: 1) renewable energy, namely downstream knowledge regarding the chemical processes for capture, conversion and storage; 2) air quality including monitoring and modelling atmospheric emissions and 3) nanomaterials for health protection, namely cancer diagnosis and therapies

LSRE-LCM is a partnership between LSRE – Laboratory of Separation and Reaction Engineering and LCM -Laboratory of Catalysis and Materials that started in 2004 as Associate laboratory. The main location of LSRE-LCM is the Department of Chemical Engineering at FEUP, which acts as the Managing Institution. LSRE-LCM has one pole at Instituto Politécnico de Leiria (IPL) since 2011, with the objective of strengthening the scientific support of the IPL members and to contribute to the development of the center region of Portugal. The mission of LSRE-LCM is to contribute towards the development of scientific and technological know-how in the Chemical Engineering areas of Separation and Reaction Processes, Product Engineering, Catalysis and Carbon Materials, Thermodynamics and Environmental Engineering. "Shaking the Present. Shaping the Future." is LSRE-LCM's motto, guiding our researchers in pursuing today's scientific challenges and innovations that will impact tomorrow's industrial and economic sustainable development. A wide range of know-how levels is covered by LSRE-LCM activities, from fundamental research to the development of industrial products and processes, including contributions from materials, process and product engineering. Training of highly skilled researchers and technicians through post-graduate and post-doctoral programs is a major focus of LSRE-LCM activities. The organization in research groups, their strategic objectives and laboratory conditions are available at lsre-lcm.fe.up.pt. LSRE-LCM is a participant R&D unit of 2SMART project and has strong expertise in: (i) catalysis and carbon nanomaterials for environmental applications, thus protecting natural resources and the urban environment to create resilient frameworks capable of resisting and mitigating the impact caused by climate change; (ii) development of new adsorbent materials by 3D-printing technology to be applied in cyclic adsorption processes, enabling beneficial impacts in the energy and ambient sectors.

CEFT – Transport Phenomena Research Center, is a research unit focusing on the sub-domain of transport phenomena (heat, mass and momentum) bridging the main areas of chemical and mechanical engineering. It assembles researchers from various Departments and Institutions across Portugal, thus departing from the traditional model of vertical organization. Since its inception in 1996, it has grown steadily, but sustainably, into a medium sized unit with an informal governance system that potentiates and promotes independent research and enhances creativity. Based at the Department of Chemical Engineering, at FEUP, during its period of activity CEFT has been classified as "Very Good" or "Excellent" by international evaluation panels appointed by FCT. CEFT's vocation lies essentially in fundamental research, in which it has achieved significant success. After in-depth fundamental studies, there have often been opportunities of applying this knowledge. It is also relevant to mention the tradition of CEFT and its vision in developing research activities with the best possible combination of people no matter their origin and place of work. This has brought us to work together with researchers with a wide range of backgrounds (engineers, physicists and mathematicians) and from a wide selection of academic departments and laboratories/groups, in Portugal and elsewhere. The organization in research groups, their strategic objectives and laboratory conditions are available at ceft.fe.up.pt. CEFT is a participant R&D unit of the 2SMART project and has strong competences in computational tools and microfluidics.

i2ADS – Institute of Research in Art, Design and Society is a R&D unit based at the Faculty of Fine Arts of the University of Porto, financed by the Portuguese agency Fundação para a Ciência e a Tecnologia. i2ADS has the mission of promoting research in Fine Art, Performative arts, Drawing, Design and Arts Education, with the core of its mission in the practical and educational impact of artistic research in society. Its main goals are the development of a research culture shared among the several artistic areas that compose it to inform and develop its practices; the promotion of debate on the social, cultural and technological frameworks of art and design; the development of research careers in Art and Design and the support to young researchers.

Together, the 4 research centers link their knowledge and resources to provide the northern region of Portugal with efficient solutions to improve the quality of life and health of citizens.














How is Artistic Research Challenging Art, Design and Science in the University?

Paulo Luís Almeida

The past three decades have witnessed the appearance of a new debating space within and beyond academic sectors. Artistic research, or research in and through the arts and design, is now solidly rooted in the research ecosystem — although not without controversy¹ —, as art and design research centres emerged alongside art-based and art-led doctoral programs. Its impact in the context of mission-oriented research and as a response to societal challenges is gaining increasing relevance. Since Christopher Frayling's seminal essay on Research in Art and Design (1993), Brad Haseman's Manifesto for Performative Research (2006), advocating for a third paradigm in research, or the recent Vienna Declaration on Artistic Research (AEC, 2020), the field has developed like a heartbeat, stretching and contracting the limits of its own discussion.

The present debate is no longer confined to the initial question regarding how or when art and design practices count as research. Or in what ways does the object of artistic research differ from the object of scientific research? As these questions remain open, we cannot but acknowledge that, like art, artistic research is an essentially contested concept. That means that it cannot be resolved by dogmatism (this definition is the right one, all others are wrong); skepticism (any definition is equally true or false, it will not change anything), or eclecticism (every definition is a partial view; the more definitions, the better). Recognizing artistic research as "essentially contested" means assuming that contradiction and contestation are intrinsic to its dynamics. This "essentially 1. I developed an extended reflection on this controversy in the chapter "Resisting Blackmail, Still... Making Art Between the Practice and Politics of Research", published in Ferreira, A. Q. (ed.). A Pintura é uma Lição sciencia potentia est. i2ADS/ Afrontamento. The present remarks are an aftermath on that previous text. contested" discourse requires us to know how to deal with the external pressures we are subjected to — the excessive institutionalization of research, the increasingly complex and ever-changing evaluation processes, and the measurable indicators. At the same time, it leads us also to recognize the internal pressures that exist in the collective beliefs regarding artistic agency, where art is also defined.

Not knowing what its boundaries are, as the inaugural statement of the *Journal of Artistic Research* pointed out (Schawb, 2011), is a reminder of the transdisciplinary nature of artistic research methodologies; the transpersonal character of its discourse within a community of practitioners; the focus on the transformative impact of its outcomes or the claim for reciprocity between the characteristics of the artistic object and the epistemic models it mobilizes.

Today, the debate is shifting as the natural differences between artistic and scientific forms of inquiry are becoming increasingly irrelevant. What gains relevance is the transformative nature of research. What is at stake is the difference between research activities that seek to ensure the status quo of their own legitimacy, on the one side, and research that questions how things are by transforming ways of knowing, thinking, seeing, feeling and acting on the other side. This transformative nature of research — the state of not yet knowing, with a desire for transformation — is at the core of art and design practices. It stems from the premise that complex phenomena and societal challenges are far more likely to be addressed if various angles are brought to bear on them.

It was not only the cultural conceptions of artistic agency that have been challenged as a result of an increasing number of artists and designers producing their artistic work in a research environment. Research procedures and our received understanding of knowledge within the University have been reformulated, alongside the abandonment of the ideal of objectivity implied by a disembodied scientific realism. In fact, the fundamental idea underlying artistic research is that we must emphasize the process of *knowing* through art and design as contrasted with *knowledge* as a steady body of propositions. Mark Johnson acknowledged just that when he argued that *knowing* in art and design is a process of intelligent inquiry into and transformation of experience (2011) to enrich meaning, open new connections, and help us synchronize our experiences.

Why does this matter?

To understand how mission-oriented research in the University can be transformative, we also need to start thinking counterfactually through the subjective mode of "what if". Counterfactual reasoning is a challenging cognitive skill through which we are able to create narratives of change by exploring the path of what happens "if...". Art and design play a fundamental role in developing these counterfactual ways of thinking in research. That happens because the cultural value of an artwork lies in the ways it relates the meaning of experience with the imaginative exploration of how the world is and how it might be. To make a decision — in art, design or science - we need to search for possibilities and be presented with options. Only after other possibilities have been discarded are we able to imagine the alternatives. This way of thinking is the ground of artistic research, as it includes art and design practices that experience counterfactual ideas in the process of making. It is also able to trigger counterfactual reasoning in the audience through art and design artefacts or performances (Reinhuber, 2023, p.2).

In research, counterfactual reasoning is what allows a state of becoming to emerge. In general, it provokes a double movement: decontextualization, in which existing elements are rendered strange; and recontextualization, in which new families of association and structures of meaning are redefined. This may happen as "a pun or homophone in language, the Freudian form in architecture, the sound in between in music composition, the both-and gestures in choreography. As Paul Carter argued (2010, p. 15), this double movement is not only the basis of invention but characterizes any conceptual advance.

What does it mean, then, to create something new as artistic research? This question was a prompt for the conference "Too Early> Too Late<" on artistic research (SAR, 2023). The answer, of course, was not the question's target but the need to emancipate the concept of innovation and the value of novelty in research towards circular or cyclic modes of creativity, to create other forms of value. It was also a trigger to artistic research's accountability in exploring different forms of artistic agency.

Where are we now? The challenge facing artistic research today is the ability to keep alive a creative practice of sensitive experimentation, an artistic way of thinking open to perplexity and non-linearity, and curatorial strategies capable of reinventing modes of political imagination and transformative meeting spaces. At the same time, to be able to represent this triangle within the constraints that the growing institutionalization of research imposes on them.

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(Des)aceleração André Rangel

Artistic Research Residency at NANO4MED, LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy.



(Des)aceleração

André Rangel

I conceived and produced *(Des)aceleração* as a relational system that combines several elements: coherent light, riboflavin, acceleration and deceleration speed, glass, photoluminescence, volume, surface, algorithm, software, and computer. This work creates specific conditions for a spatial, optical and chromatic experience, creating a visual experience resulting from the coincidences of the predicted and determined with the unforeseen and indeterminate — the coincidences of order with chaos.

My artistic work operates hybrid processes of thought and action, determined by the constraints and affordances that constitute the diverse ecosystems in which I find myself at any moment. Driven by the intrinsic motivation of elaborating interchangeable questions and answers, I am guided by my curiosity for the unknown, uncertainty and serendipity — I don't know my work until I make it, I don't know its aesthetic power until I present it.

I create artistic experiences that are open and autopoietic systems. In their processing, as a human, I am just a resource, one of its means. I move in and with these systems in constant iteration between subject and object states, organizing and reorganizing the organism-system and my own organism. These are dynamic intermedia fusion systems in which I invariably resort to computer programming as a syntax that integrates the means used. This syntax manifests itself not only as an active form of transmutation and as a language of action that gives activity and autonomy to artistic hybrid systems of living and non-living beings — mechanical, electronic or computerized. P. 42 (Des)aceleração, laser-colloid-glass generated image.

P.45 (Des)aceleração, laser-colloid-glass generated image.

 The experiments with cobalamin and thioflavin, at NANO4MED lab, triggered my curiosity and made me explore beyond the lab space and its resources in order to experiment with riboflavin.

 Petri dishes — used for bacterial cultures — are not part of NANO4LAB utensils but in my imagination and memory they are associated with laboratory activities. The hybrid and fluid procedural nature of the intermedia systems thus created is generated in experimental processes and methodologies, where artistic and scientific experimentation go hand in hand given that artistic research, such as the one I developed in this residency, is composed of experimental, laboratory, transformative, synthetic and subversive acts.

In this residency, as I invariably do in my work, I turned to the transformation and subversion of the original function of media, creating new thoughts, ideas and functions for already existing media: riboflavin,¹ with a biological function in living organisms, started to function as a light and energy modulator; the petri dishes² that, in microbiology laboratories, isolate growing bacteria, began to serve as a glass, a reflector and refractor of light, and as a "pixel"; the vertical exhibition plinths of the FEUP library exhibition room were laid down and composed in a single volume, functioning as a horizontal base that justified the alignment of the petri dishes; the exhibition room became part of the exposed object itself; or the audio interface that becomes the laser interface.

Like a scientist, I apply methodologies and test hypotheses. The means, questions and inherent answers that constitute my artistic research are actually and virtually available. I act by operating a selective, transformative and relational articulation process, which leads to the emergence of the new. In *(Des)aceleração*, as in my other work, I conjure up materializations that make the answers tangible, actualising the questions that motivate my creative process.









NANO4MED

Joana Loureiro

The research at the NANO4MED laboratory mainly focuses on developing novel drug delivery systems based on nanoparticles for health applications. The group has designed and produced different types of lipid and polymeric nanoparticles to target neurological diseases and cancer tissues. Additionally, in recent years, nanoformulations to be used in cosmetics and nutraceuticals have been developed.

The main contribution of the NANO4MED group to the 2SMART project was focused on the development of smart materials for cancer prevention and therapy. This project aimed to develop an effective nano-delivery system for brain tumour therapy able to transport bioactive compounds. Brain tumours are aggressive tumours with poor survival outcomes, and nanoparticles for drug delivery are promising strategies to enhance therapy efficacy by improving drug bioavailability and reducing drug toxicity. In this project, functionalized nanoparticles were developed for brain targeting. To that end, molecules were used as targeting moieties to enhance the transport of the nanoparticles across the blood-brain barrier and internalization in the target cells, allowing for an increase in the nanoparticles' bioavailability.

During the artistic residency developed by André Rangel, the artist had the opportunity to observe the investigation that the NANO4MED researchers developed in the laboratory. The researchers explained what they do under their research projects and also what they are developing under the scope of the 2SMART project. Based on the work that

P. 46-47

(Des)aceleração, riboflavin colloid excited with coherent light (laser) with a 445 nm wavelength.

P.48

(Des)aceleração being assembled at the Library of the Faculty of Engineering, University of Porto, 2022.

P. 51

(Des)aceleração, riboflavin colloid excited with coherent light (laser) with a 445 nm wavelength. was performed using vitamin B12 for the treatment of cancer and neurological disorders, André could idealize (Des)aceleração. Vitamin B12, also known as cobalamin, is a water-soluble vitamin that plays an important role in many bodily functions. It is essential for the formation of red blood cells, DNA synthesis, and the proper functioning of the nervous system. Vitamin B12 is not produced by the body and must be obtained through food sources such as meat, fish, dairy products, and fortified cereals or through supplements. The artist used this molecule, which is fluorescent, and represented a fluorescence analysis in a fluorescence microplate reader using a 96 well plate. Those fluorescence analyses are mainly used to quantify the amount of bioactive compounds encapsulated in nanoparticles. André could interpret the colours, the equipment sounds and the researchers' excitement when waiting for the results report.

This artistic residence was an opportunity for the NANO4MED researchers to interpret and observe their works also as a piece of art, even when the results are not as bright as vitamin B12!









Bacteria are Said to Travel in Light

Gabriela Vaz-Pinheiro

"And a practical question: there are such huge consequences for each of us to know if the beings one suggests or has suggested, dreams or desires — to know if they exist in the world of dreams or in reality. And if in reality, then in what reality? What kind of reality is being set up to receive them, is present to sustain them, or is absent to annihilate them? Or, if one mistakenly considers just one single genre, if one's thought lies fallow and one's life is left unable to inherit these vast and rich existential possibilities".¹ Etienne Souriau

The project 2SMART, engineered smart materials for smart citizens, funded by NORTE 2020, coordinates four R&D units of the University of Porto: LEPABE, LSRE-LCM and CEFT at the Faculty of Engineering; i2ADS at the Faculty of Fine Arts.² It is a program that stimulates cross scientific production, that is, the production of research that assumes methodologies from different origins seeking to present its results (and concerns) in unusual ways for each of the fields involved. On one hand, we have materials engineering, a fertile soil, crucial in a time of extractive exhaustion of resources and of constant reformulation of our material, visible and invisible, relationship with the world. On the other hand, we have the need to communicate (and communicate visually) the processes and results of the sciences that frequently use images for that purpose. Finally, this process also crosses with artistic research, to which the visual possibilities matter, but to which also matter the laboratory procedures and methodologies developed by science that may constitute concerns that artistic research can use.

P. 52-53

(Des)aceleração, view of the exhibition at the Library of the Faculty of Engineering, University of Porto, 2022.

P. 54

(Des)aceleração, laser-colloid-glass generated image.

1. Etienne Souriau, Les différents modes d'existence, pp. 9–10, quoted by Bruno Latour, "Reflections on Etienne Souriau's Les Modes d'existence", in Graham Harman, Levi Bryant and Nick Srnicek (eds.) The Speculative Turn, Continental Materialism and Realism (Melbourne, re.press, 2011, pp. 304–333. Quote on p. 313).

2. LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy; LSRE – Laboratory of Separation and Reaction Engineering and LCM – Laboratory of Catalysis and Materials and CEFT – Transport Phenomena Research Center, Faculty of Engineering, University of Porto. i2ADS – Institute of Research in Art, Design and Society, Faculty of Fine Arts, University of Porto. With this short text I hope to demonstrate that the symbiosis is fruitful for any of the fields concerned and that working from their institutional contexts and specific systems, is, ultimately, in the connection to society that both science and art can intersect.

(Des)aceleração, by André Rangel, was the first exhibition resulting from the 2SMART project and consisted of a two-month residence at the NANO4MED laboratory of LEPABE and an exhibition running from 18th of May to 17th of June 2022 at the exhibition room of the Library of the Faculty of Engineering of the University of Porto. There are several possibilities to write about this work, from the experience of the visitor confronted with an immersive and engaging situation, to the attraction of the laboratory and/or technological means of the so-called rigorous science that is so appealing to artistic practice (and vice-versa). There is the historical retracing of artistic practices, certainly since at least the second half of the 20th century, which incorporate such means. There is the problem of the dematerialisation of the work of art. There is the insufficiency of the entry point into reality that technology, without a humanised dimension of experience, offers us. But I will start by talking about blindness.

André Rangel speaks, in his text on this work, about the fascination with a blind part of a laboratorial process that he found at LEPABE. A kind of black box inside of which the process being studied is developed, to be debited and interpreted under a visual form on the other side, as if traversing a tunnel to present us with a final revelation. Reaching daylight becomes a point of arrival. As if it was necessary to counteract darkness. In fact, the evocative capacity of the installation, by crossing sound and light with objects and space, allows for the creation of an immersive experience in which the observer wonders about the cause-effect relationship of the phenomena he or she witnesses. The body of the observer as trigger of that experience is positioned spatially and this is one dimension that the installation actively engages. In fact, matter becomes a category that is well beyond its strictly physical attributes, it passes to a figurative and evoked sense through the time and movement that light and sound imprint on space and that the observer's body retraces as it evolves in the room. But the dematerialisation of the work is not only an occurrence that dispenses, at least in part, with objecthood, it is also a coexistence with the form of thought that philosophy expresses or with the dimension of experience that phenomenology seeks.

André Rangel reveals that his methodology has been formulated in the process of engaging with the laboratory context in which he found himself in residence. This openness to context presupposes that the subsequent programming corresponds to a compositional development that makes use of the power of digital systems, taking technical reproducibility, traditionally associated with the diffusion of images, to its dimension of algorithmic language, that is, to its electronic reproducibility, with which we are already very familiar. We know that movement, sounds and light are the perceptive manifestation of codes. And we also know that in the process of dematerialisation of the work of art, which the last century witnessed, the idea of immersion and virtuality were its underlying derivation.³ The big difference between the comprehension of conceptual art in the second half of the 20th century and the immersive consciousness of today, is that the observer began to understand with the body, and to understand that the body, as an intrinsic part of the immersive experience, is under the effect of information. In this intangibility, a perceptive maturity has been formed that our anthropological awareness has not yet resolved.⁴ When in 1970 the MOMA organized the exhibition Information, the goal was to call artists that were "part of a culture that has been considerably altered by communication systems such as television and film, and by increased mobility".⁵ This sentence sounds profoundly current if, by extension, we add to those systems the algorithmic dimension.

 For the historical framing of dematerialisation of the work of art see Lucy Lippard & John Chandler, Six years: the dematerialisation of the work of art 1966 to 1972, (University of California Press, Berkeley, Los Angeles, London, 1973).

4. See the situation generated by the recent forms of image production based in Al, a topic that overflows the editorial space of this text but that surely needs urgent critical approach.

5. Text in the catalogue edited by Kynaston L. McShine: *Information*, (The Museum of Modern Art, 1970: Acknowledgments). 6. Jeanne Siegel, "An interview with Hans Häacke" in *Arts Magazine* 45, no. 7 (May, 1971, p. 21).

7. John Law, After method, Mess in Social Science Research, (London and New York, Routledge, 2004, p.2). The growing awareness that information is what currently controls us has been formed already in the 1970s. Hans Häacke, whose work, as we know, had been removed from the aforementioned exhibition due to having touched a politically sensitive topic of the art system, says in an interview for Arts Magazine in the following year:

"Information presented at the right time and in the right place can potentially be very powerful. It can affect the general social fabric. (...) The working premise is to think in terms of systems: the production of systems, the interference with and the exposure of existing systems. (...) Systems can be physical, biological, or social".⁶

To work contextually is to work from systems, taking them apart, re-equating the information that is produced in them, to reach forms that allow us to reposition our perception of the world we inhabit.

And what can art do in the face of this world?

Here, it could recover what John Law says about the social sciences. He says: "the world is (...) textured in quite different ways. My argument is that academic methods of inquiry don't really catch these. (...) Pains and pleasures, hopes and horrors, intuitions and apprehensions, losses and redemptions, mundanities and visions, angels and demons, things that slip and slide, or appear and disappear, change shape or don't have much form at all, unpredictabilities, these are just a few of the phenomena that are hardly caught by the social science methods".⁷ Therefore, these dimensions — that bring such disguiet to the so-called rigorous sciences - as if they are a part of the world that stands outside the production of knowledge, seems to be a legacy for art to grab and reformulate. To work from a given context allows artistic practice to base its concerns on a set of data and situations generating what André Rangel calls a "conversation (...) in a process of mutual

transactions with the situation — with matter, materials and ideas." Therefore, in what way can we think about technology and the laboratorial means if not at the service of a greater form of belonging that incorporates the world's experiences in their telluric and expanded connection that does not exclude the places of others from our place in the world? It does not seem hard to me to extrapolate such consciousness from an interchange like the one promoted by the project 2SMART, because what other motivational reason would move us beyond a communion of future to which all production of knowledge always moves towards? I would be interested in thinking of the mutual benefits resulting from the intersection of these practices and methodologies, but I am also interested, and maybe even more so, in the certainty of the benefit to society that both, in that intersection process, may produce.

P. 60–65 (Des)aceleração, details.













HMV_II Catarina Braga

Artistic Research Residency at Environmental Sciences and Technology, LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy.



HMV_II Catarina Braga

HMV_II takes its name from Stanisław Lem's science fiction novel His Master's Voice (1968), in which a team of scientists and experts are brought together to investigate and decipher a message sent from space, at times referred to as the "letter from the stars". The code name for the project becomes "HMV" (His Master's Voice) and as Peter Hogarth, the main character and the leader of the team, recounts the progress of the investigation we realise the team's frustration and uncertainty reflects the fundamental challenges of communication and the limits of human knowledge and experience.

The effects of the isolation imposed on the scientists, the projection of human fears to the "letter" — which is believed to be sent by an alien civilisation —, the attempt to translate the message into an organic matter — which they managed — and the way they want to instrumentalize this matter for destruction and war, show us how limited we can be in our human understanding of other life forms.

Science fiction stories are oftentimes fuelled by the quest of exploring an unknown and vast universe, with a desire of encountering alien life forms. But what if this alien life form is already present in our planet? What if air is not what we have come to believe it is, and instead is a more complex collective organism, a multispecies entity, capable of binding us to each other and establishing its own time and space?

P. 68

HMV_II, view of the exhibition at the Library of the Faculty of Engineering, University of Porto, 2023. P.71 View of HMV_II. *HMV_II* shows us a fictionalised laboratory where a scientist has dedicated their life to define the complexity of the air life form, compiling research made at the end of the 21st century — displaying the real research and data collected by the team from Environmental Sciences and Technologies research group at the Laboratory for Process Engineering, Environment, Biotechnology and Energy (FEUP, Porto), between 2018 and 2023 — and the affective relationship they were able to establish with air. The scientist looks back at our present time and our century, reflecting and critiquing the obstacles we face when we try to break free from our limited human understanding of life.

The idea of a future is also experimented here. From volcanic rocks to seeds to plants and books, this laboratory aims to be an attempt to identify a complex subject — our collective experience of being.

Just like the "letter from the stars" in Stanisław Lem's novel is described as a series of mathematical symbols and equations, as well as diagrams and images that are difficult to interpret, scientific data created around air and indoor air pollution measurements are just a part of decoding what air might really be. The fragments displayed blend different fields of knowledge and different bodies, which allowed each of us to create our affectivity with it and complement one's relationship with air.






P. 72–73

Catarina Braga, *First Aeriform* (2124), 2023. UV printing on Dibond, 70 x 62 cm.



Environmental Sciences and Technology

Sofia Sousa & Pedro Branco

The Air Quality and Health research team, part of the Environmental Sciences and Technology group at LEPABE, has over 20 years of experience studying air quality and health. With a strong focus on generating scientific outputs with significant societal application and positive impact, this team has conducted scientific research in various areas in such a broad topic, coordinating and participating in several national and international projects whose main targets go from the study of air pollution emissions to smart monitoring indoor and outdoor air quality, and to the quantification of the associated health effects of air pollution exposure. Recently, this team has been dedicating significant efforts in conducting research on the use of emerging smart low-cost sensing technologies for indoor air guality (IAQ) monitoring in schools.

Within the 2SMART project, this team was responsible for activity 2, which intended to develop a smart low-cost device to reduce children's health risks from indoor air pollution exposure in schools, with scientifically calibrated and validated sensors, capable of interacting with the end-users. Cities require comprehensive air quality data to reduce health risks for citizens. Low-cost sensing technologies are emerging as a smart solution for real-time monitoring and management of air quality. This can engage citizens in mitigating air pollution, especially indoors where people spend more time. Addressing indoor air pollution in schools is crucial for preventing childhood diseases. Poor indoor air quality has been commonly reported in nursery and primary P.74 View of HMV_II. P.77 View of HMV_II. schools, and associated with negative impacts on children's respiratory health. Schools can self-manage IAQ with appropriate information and tools. Smart low-cost sensing technologies offer a promising tool for this purpose, but current solutions have limitations compared to traditional monitoring methods. The research conducted involved the selection of the low-cost sensors based on scientifically validated criteria, the design of the sensor system architecture and corresponding prototype, and the development of advanced calibration methods using machine learning techniques.

As part of the project, an artistic residency was conducted with artist Catarina Braga. She spent time with the Air Quality and Health research group to learn about the work developed in the IAQ field, experience the use of the newly developed prototype of the low-cost sensor device, and participate in in-field monitoring campaigns at nursery and primary schools. This artistic residency resulted in an exhibition, *HMV_II*, which explored the complex nature of air and our relationship with it, highlighting the interdisciplinary nature of research and the value of collaboration between art and science.









How to Make the Air Visible

David Lopes

Catarina Braga's work often concerns questioning human perceptions of the world. Her projects follow a post-modernistic voice by bringing to reflection what is objective truth and what we deem reality to be. Following iterations on the same line of thought, we come to some of the questions that keep fascinating her: what are the consequences of technology to humans' perception of the world? and how has past technology been moulding our current understanding of what is natural and what is artificial? This has been shaping Catarina's practice, leading her to build a consistent body of work around the idea of constructed nature.

Between 2016 and the end of 2019. Catarina lived in Shenzhen, China. Born in a Western-European country, I believe she was captivated by the adventurous opportunity to experience a different culture, language, and a different political context. Knowing her for a few years now, I don't place the need to live abroad for the purpose of self-discovery, but to challenge herself to a different perception of the world. Prior to moving to Shenzhen, she was anticipating her journey to China; I remember she presented Ensaios sobre a distância (Essays on Distance), 2016, a photographic installation and publication of traces of Chinese immigration in Porto, and even photos of her visiting China, where her sister lived.¹ While living abroad, she shared with me how she was experiencing the differences between European and Chinese contemporary culture and art. Catarina understood Shenzhen's art scene to be predominantly dominated by commercial goals: the dominance of capitalism. Not withstanding the feeling of

P. 78–80 Views of *HMV_II*.

 Catarina no longer holds an on-line record for this project, but you can still see it in Susana Lourenço Marques's blog *Esquerda-Direita-Esquerda*, entry from February 2017: https://esquerdadireitaesquerda. wordpress.com/praticas/asfotografias-os-livros-e-o-resto https://catarina-braga.com/
The-World-is-not-the-World.

3. Catarina's work if a tree falls in a forest and no is around to hear it, does it make a sound?, 2019, recently acquired to the collection of Serralves explores the recent polemic of political wrong-doing over the Amazon forest (Valsassina, 2022). displacement, Catarina exhibited regularly in Shanghai and Shenzhen between 2018 and 2019, as she sought the opportunity to bring her practice to a place where it would probably be considered alien.

The World is Not the World,² shown in 2019 at the Banana Jam Gallery, in Shenzhen, felt as a culmination of her reflection on nature up to that point: not only addressing the perception of nature by humans, but also how we create technological extensions of natural concepts, such as landscape. Let us focus on her artwork *Neutrality 100%*. The checkerboard background of Adobe's Photoshop is presented next to a photographic natural landscape of the ocean, enticing an ironic comment on how we perceive landscapes as screens, and how natural deserted landscapes feel as empty digital backgrounds.

Caring for what is the representation of nature appears to be a common stand in Catarina's work, in a way that reflects not only a much-needed awareness of ecological problems,³ while, at the same time — at least at this stage of her practice, — seems to reflect an urge for philosophical maintenance of what landscape is. The use of grids, for example, call back territory mapping, and indeed historically speaking, and ever since Ptolemy, humans have grown to represent the territory by dividing it into parallel lines going vertically and horizontally (Rees, 1980).

Catarina came back from China right before the pandemic spread around the world. From then on, she has been exhibiting in Portugal, where she kept on reflecting about the impact of technology and the representations of nature. In her work, we should also be aware of a constant assertion of dualities: natural vs. artificial, real vs. fake.

As I understand it, certain objects, materials, concepts or ideas are linguistic miscellaneous to all of us, and that seems to trigger Catarina's creative process. Let us look at *Growth Room*, also presented in Shenzhen in 2019, and later in Guimarães in 2022.⁴ The installation covers the entire room with mylar fabric and the space is lightened with led lights used for the growth of plants, glowing up the room with the red and blue light. The sense of entering a technological space is unavoidable, yet it coexists with knowing by reasoning and context that this is an ideal environment for the growth of plants.

The installation is a symbolic play with humans' perceptions, creating conflict and discomfort, ultimately trying to make our human bodies feel like plants.

Experiencing HMV_II

HMV_II is a numbered acronym after the novel *His Master's Voice* by the science fiction writer Stanislaw Lem.⁵ Just like in the novel, His Master's Voice_II is a code for us to decipher.

The space welcomes us to a frontal and panoramic space, backlit by a wall of glass windows. There is no real path to follow along the exhibition, but it seems to be designed in a way in which we could read objects in separated nuclei. Showcase tables display simple objects: plant leaves, volcanic rocks, open notebooks, and printed text on simple reprographic paper sheets.

A few metal shelves articulate what could be another nucleus, making the composition in the space. On top of the shelves, materials are placed in a non-rigid manner, arguably emphasizing a sense of recent use: as if someone will come back later to tidy up the space.

In the centre of the exhibition, a section of objects is on display framed by a mirror on the floor. On top of it, a small portable machine is active: analysing the air in the room in real time: taking measures of the concentration of CO_2 and other microparticles. Scientists and researchers from the Environmental Sciences and 4. Catarina Braga, Growth Room (2020–2022). https://catarina-braga.com/ Growth-Room

5. Catarina alteady holds an online record of the project online. https://catarina-braga. com/HMV_II 6. In this curricular exhibition, organized by artist and professor Miguel Leal in 2016, Catarina presented two polaroid pictures of plants inside the building space, which held most of the works. The pictures depict the outside garden with two plants at the centre that had been planted by Catarina. One of the plants was artificial.

Technologies research group at the Laboratory for Process Engineering, Environment, Biotechnology and Energy have developed this prototype machine in the context of 2SMART, to measure the quality of the air inside school classrooms of the north of Portugal. At the exhibition opening, I had a chance to listen to the lead researcher Sofia Sousa as she explained to a group of visiting people that the machines like such do exist in the market but are not reliable. According to her, the first part of the research focused on identifying discrepancies between available products to the general consumer. The results proved conclusively that the products available to the average consumer are not trustworthy, although they are indeed marketed as efficient because they are still profitable within a capitalist system. After building their own device, and with control over the quality of measurement, the team of scientists were able to gather more rigorous information. Results showed that regular classrooms do lack the infrastructure to provide the quality of indoor air required by European laws. CO₂ and other microparticles were even higher than values recommended by Portuguese laws, which according to Sofia Sousa are lower than those demanded by European laws. Next to the device, the graphs obtained in research were printed and exhibited.

Plants

The presence of plants has been a common practice in Catarina's work for the past few years. Scattered around the exhibition, the strategy here is slightly different: plants are not shown to pose as symbols of representation for nature, nor are they a mixture of real plants and artificial ones, as shown in the exhibition like *The World is Not the World* (Shenzhen) or *Jardim do Éden* (Centro Hospitalar Conde Ferreira, Porto).⁶ All plants are real, from different species, each one contributing to understand the impact they have on their environment's air. The selected plants actually purify and improve the air quality by removing chemicals and dust that contribute to indoor air pollution. Their presence is intended to make the air visible.

All of the plants actually belong to Catarina and are a constant company in her studio. I should underline that taking care of plants and learning about them, makes it a very simple gesture and yet a powerful tool that is crucial in Catarina's creative practice. In her academic writing, she used the word preservation as an adjective to the act of planting, following Flusser's ideas (Braga, 2023, p. 44). But Catarina is very aware of the dual perception of plants as living organisms and their role as conventional decorative elements for indoors (Esteves, 2022). With it, we should also be critical on our part: as we take care of plants within a capitalist system, somehow oblivious or indifferent to the fact that the system is the primary obstacle in solving the pressing ecological crisis. I believe Catarina's plant installations have always been a form of reflection on this social construct.

Over the years, her interest in botany and biology has been feeding an ever-lasting curiosity that is helping her challenge her western-based perception of plants. Research takes form into actually taking care of plants, which organically have been migrating to her exhibitions. It works both in making herself and others aware of the social constructs of how we instrumentalize plants.

Catarina made taking care of plants a studio practice, without ever actually changing the procedures that normal gardening would carry out.



	feeling the grass
	carrying seeds
-*-	moving clouds
	erasing footprints
	blowing hair
	gentle vortices
_	caressing skin
	cleaning lungs

The air's daily routine chart for a happy life

The Fictional Scientist

There is a novelty in Catarina's work presented in *HMV_II*. Over the past year she has been inventing a character living in the future, a scientist. It should not trouble us to figure out what the character looks like, what gender they are, what they identify as. The important aspect I should try to grasp here is that Catarina wrote this character with the very specific intention of them living in our future, from whom we can access the perception of what a future civilization thinks of its past.

A text on display titled A semântica do ar (The air's semantics) is presented to us almost as a note diary entry in the exhibition *HMV_II*. How to make the air visible, the title of this text, is named after Catarina's written sample of this fictional text. Here the character is speaking to their readers (whomever they might be), explaining how they first approached the air as an external element to the human body, growing to recognize it as a sort of tissue from which we humans cannot be disjointed.

The scientist also mentions an influential text that has shaped humanity's views on this matter, **"What is one and what is many, and what is the other?"**. With it, Catarina created a sort of prophetic thesis to come in the nearby future, — more precisely in 2056 — holding the promise of being one of the most influential writings in shaping future generations' understanding of what it means to be alive and what is the world.

Through science-fiction Catarina takes us into her abstract mind-site, that often grounds her questioning and creative practice.

P. 86

David Lopes, visual scientific graph created by FEUP's The Air Quality and Health Research, appropriated to create visual poetry.

P. 89

David Lopes, school assignment interpretation placed in Catarina's fictional future.

Sampling and Chaos

I found it curious to understand that there is still a need to explain how art and science can work in a shared dialogue, as if there is a general perception that their relationship is somehow unseen, and only projected by the evolution of modern ideas. We still dichotomize what we understand as factual and what we understand as sensorial.

One of the key ideas to be taken from Catarina's *HMV_II*, is the possibility to navigate between scientific discourses and a poetic understanding of nature. On talking about Goethe, Didi-Huberman explained how his work was both capable of reaching the pursuit of scientific knowledge while being aware of natural sensorial qualities. In addition to this, Didi-Huberman argues that we cannot explain a natural phenomenon by itself, and only on itself, we need to gather different phenomena (2011/2013, p. 137). Here, the writer's mind is on Aby Warburg's *Bilderatlas*, but his goal is really to argue in favor of understanding multiplicity using an atlas, and by which a montage is a tool of major importance.

Much like what we see in Catarina's exhibition, objects of different natures: plants and the written word, scientific graphs, are articulated in order to make the spectator aware of the air's presence. To make something so abstract as the air understandable, one object alone is not sufficient, thus the emphasis on the need of an atlas, capable of shifting between chaos and sampling — *monstra and astra* —, as Didi-Huberman would have put it (2011/2014). Catarina's formulation of an exhibition works much like an atlas: always unfinished and open to new montages.

today at school, my daughter made a greeting card.

She said,

she wanted to

welcome a warm

breeze

7. Founded by Carolina Grilo Santos (b. 1993), Diana Geiroto Gonçalves (b.1991) and Luísa Abreu (b. 1988) in 2020, with funding by DGARTES.

Exhibiting in Scientific Spaces

HMV_II, shown in March 2023, at the Faculty of Engineering of the University of Porto's library hall, is one part of the three projects selected by 2SMART to take part in residency programs, in which artists are selected to work within a scientific laboratory.

The scenarios in which artists and scientists might collaborate make up different contexts to reflect upon. Some of the variables could go into: (a) exhibiting art-related objects or non-scientific objects in scientific spaces; (b) exhibiting objects of science with an artistic scope, (c) making art from or about scientific spaces. Catarina's exhibition deals with all these topics.

Projects such as these can potentially challenge the disciplinary roles that we attach to ourselves as professionals and even as individuals, but none of this is a new territory to contemporary culture. Just in the past couple of years, the city of Porto held two exhibitions with artist-in-residency programs taken within two scientific institutions. Organized by Paralaxe,⁷ the exhibitions, publications and events followed a very similar premise.

In Portugal, projects such as these can easily be traced back to Marta de Menezes's final project for her BA degree **Nature?** (1999–2000). The work consisted in a greenhouse with plants and butterflies. It was developed within the laboratory facilities at the Evolutionary and Ecological Sciences of the University of Leiden in the Netherlands. Specifically, the lab team was researching how to change the visual patterns of the butterfly's wings, and Marta had the opportunity to do it herself in one of the butterflies' wings. The revolutionary process in which Marta participated shouldn't be overstated: the artist fully inhabited the laboratory as her studio, working with the actual tools and research available from the lab's structure. Marta's *Nature*? parallels much with Catarina's work, because it also presses awareness on how we humans craft and blur the boundaries between what is natural and what is artificial.

Other noteworthy examples are projects which derived from *Experimentação: Arte, Ciência e Tecnologia*, a partnership between DGARTES and Ciência Viva, in 2007 and 2010, offering opportunities to eighteen artists to work within scientific laboratory facilities.⁸

Here, we should perhaps focus on the work developed by Herwig Turk, who had been collaborating with the scientist Paulo Pereira⁹ for over a decade at that point. The two worked as peers in exhibitions, meaning that Pereira was not a mere collaborator to Herwig; something unusual for this kind of project, where the scientists are normally just facilitators, removing themselves from a critical and a creative authorship.

Paulo and Herwig shared creative input and decision-making in producing a series of exhibitions together, as shown in the publication *Blindspot* (2007). Their basis was to challenge the perception of the laboratory space, and to bring the objects, the gestures and the scientific language to different settings of perception.

Blurred Heritage, or Final Notes

The relationship between art and science is historically too complex to categorize, not only in chronological terms but in what is the accurate understanding of science and art collaborations.

Our conception of art today differs largely from the art produced in the Renaissance for example: and yet many still remark it as a period in which efforts sought to bring scientific knowledge and art-making together. In the mid-70s, philosophers Arthur Danto and Hans Belting spoke about the "end of art", as the end of narrative art-making. To their understanding, art existed before mostly as a manifest of a godly presence and less as 8. Experimentação: Arte, Ciência e Tecnologia: 1st edition projects can be seen at: dgartes.gov.pt/arteciencia/ Index.htm. The 2nd edition results can be seen at: dgartes. gov.pt/redederesidencias/ index.htm

9. Paulo Pereira teaches at Faculdade de Ciências Médicas, Universidade Nova de Lisboa. if it weren't for *war,* and their need to claim lands,

I would've believed they invented *flags,* so they could see the **wind.**

a journal entry from March 24th 2062.

testimony of humans' marks. What they meant indeed was not the actual *end of art*, but the closing chapter of the understanding of what art should be.

Contemporary artists have been heavily shaped since modernism; a shift which contributed to other debates, along with other definitions such as post-modernism. Another critical point is the writing of Rosalind Krauss, which grounded the paradigm of the post-medium condition. Today artists find themselves less interested in having a practice ruled by mediums, as their work diversifies in transdisciplinary, interdisciplinary and multi-media installations (Arnette, 2016). But by contrast to modernism, Danto would add that "contemporary art (...) has no brief against the art of the past, no sense that the past is something from which liberation must be won (...)" (1997, p. 5).

The paradigm we find ourselves today is respectfully following several of the available pathways for art-practice to be connected to social different spheres. The growing interest in scientific labs or institutions is really a reflection of artists accepting a blur mission within post-medium or post-modernism legacy of contemporary art, which encompass a lot of goals: the questioning of knowledge, the intersections between social and disciplinary spheres, the questioning of museum and institutional structures, and others to come.

The educational purpose of contemporary art exhibitions is often pointed as an argument in favor of projects that intend to link art and science. In Switzerland, there is an on-going active program called *Artists-in-labs*, founded in 2003 by Jill Scott,¹⁰ who has already published several books on the subject. Reading general writings on this artist-in-residency program, we can find statements on the positive impact on both the scientific and artistic community, as well as on the general public. Scott (2015) has talked about how scientists find new ways to com**P. 92** David Lopes, a fictional journal entry from 2062.

10. artistsinlabs.ch/en/ See the edited books and monographs by Jill Scott at: https://jillscott.org/publicationseditedvolumes.html municate more efficiently their research, just by having to interact with artists. The dialog between artists and scientists is argued to be opening the door for a more participatory society: peering the two together to create exhibitions and to promote a debate of what is scientific research, what is needed to be ascertained for a socially rightful perception of it, and what are their ethical limits of the pursuit of knowledge, and such is communicated to the public.

However, I should underline how this positive reading is not all aligned with everyone's understanding.

In 2021, I had the opportunity to interview Paulo Pereira, the scientist mentioned earlier who worked with artist Herwig Turk. In his understanding, there is no real interest in looking at the relationship between art and science as beneficial for better communication of scientific concepts. "I think that there should be mutual discomfort, if well negotiated, it can bring very interesting reflections to the table, eventually very interesting works. There is more in common that most people consider, and the differences (between Art and Science) are sufficiently large to allow the two not to conflate." Pereira argued more in favor of a less boundary-disciplinary dialogue, stressing more importance in the possibility of critical conversation on subjects that belong to society as a whole, not just to scientists or artists.

Catarina's *HMV_II* clearly shares the same critical reflection communicated so properly by Paulo Pereira. Like much that Catarina has presented, Paulo and Herwig's collaborations sought to make visible the "fallibility of scientific conventions and highlights the importance and contribution of social and individual constructs (constellations) to what is perceived as a scientific truth or a scientific fact." (Pereira & Turk, 2007, p. 5). Such an approach is visible in Catarina's fictional lab from the future, existing in a timeline that challenges the perception of ourselves. This is hardly a pursuit with the intention to over-throw science or art establishments. It is a reminder to what it means to be aware and capable of critical thinking. **P. 96–101** Views of *HMV_II*.

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by division and differentiation Carolina Grilo Santos

Artistic Research Residency at Processes, Products and Energy, LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy.



by division and differentiation

Those First Steps Towards

Carolina Grilo Santos

It is curious how sometimes we must drift away and get lost to return to the same point more confident than ever.

The course of this adventure began with this title (*Those first steps towards*) and the idea of a docufiction movie. It went through phases of desperation, zero ideas, and confrontation, and in the end, a docufiction with a different name was born, voiced by blue thoughts and doubts, captured through warning lights and flashes of not yet hatched memories.

Since 2016 I have been crossing art and science-related concepts. From astrophysics to geography, maps continue to look challenging and mathematics worth admiring. It kept getting interesting, it kept gathering colleagues around my ideas, even when I was not sure. My passion for it grew strong: I searched for teams to work with and co-founded Paralaxe project, where I am happy to share all this with more artists. So when people ask me about the expectations of working in and with a laboratory, I know part of it is filled with anxiety from my romantic visual fascination. But, dear reader, I wanted you to understand that nowadays it has more to do with collaboration and time to perceive others' thoughts, passions, and methods.

I have been in great and diverse research fields and contexts. However, LEPABE – Processes, Products and Energy brought me to a modern dynamics laboratory where nothing is museum-protected and problems are being solved *in loco*. It is a *school* of learning by looking P. 104 Residency fieldwork. 1. Dispositivos de medicão fantasma (Phantom measurement devices) is an installation by Carolina Grilo Santos included in the group exhibition Whether the Weather at the Geophysical Institute of the University of Porto (2021). This exhibition linked artistic practice with the means of scientific investigation and, through intruder-creations, activated the meteorological park, once populated by manual measuring instruments.

2. 52 Hertz W is an artist's journal included in the project Paralaxe: Astronomical Observatory (2022). This newspaper was conceived from the residence in the space of the Astronomical Observatory Prof. Manuel de Barros and included in a set of seven individual artist journals; in this, curiosity for extraterrestrial life, the visceral and internal life of the body and the unknown underwater life are crossed, starting from the case of the "loneliest whale in the world" to think about (poor) communication and (complete) mismatch with other beings and forms of relationship.

at things and actually touching them, a context in which I had never worked. My first impression was shaken by fear of not getting comfortable around all these complex machines and clean surfaces, fear of making mistakes, ruining investigations, or disappointing someone. The fear of not finding the astonishing beauty one imagines.

Those first steps towards the creation of *by division and differentiation* were filled with analysis of my emotions and holds, the alien-like feeling and magnetism, the crystallizing of a bond that is not easy to put into words, especially for an artist and a team of scientists. These bonds and relations with space and its people became important to me during my career: the understanding that the emphasis must be on collaborating and sharing. This is clear with *Dispositivos de medição fantasma*,¹ when 15 artworks *reactivated* an old meteorological park, for example.

by division and differentiation is not only a short film created faithfully to my truth and with beautiful images of a laboratory. It means to be a call for slow driving and appreciation of invisible things right in front of us, a new vision and understanding of the landscapes and issues these scientists cross daily, a poetic view on science that is, in fact, my way to create and love these scientists, their goals and accomplishments.

The concept of alien, intruder, or outsider travels from $52 \text{ Hertz } W^2$ and it is linked to my inner experience during this residency. by division and differentiation breathes this through an alien ghost character reporting its arrival on Earth, its desire to be rescued, and the process of adapting. Over this journey, machines, objects, and gestures of research are highlighted by their weird beauty: a solar simulator, droppers, welding metal, or centrifugation. The concept of other/unknown is also important, not only through the idea of this intruder — which is a voyeur documenting and observ-
ing — but also through instruments of platonic interest, unfamiliar perceptions, and decontextualized mutable concepts once static.

As I conclude this reflection, I must get back to the question of what my expectations are in working with laboratories and how they shape my will to share experiences. As creator of this short film and exhibition, creator of selected cover art for one of the LEPABE researchers. and artist in residency who organized presentations and hung together with them, I must say that every move went accordingly to my desires of inhabiting a warm place icy to poetry. I felt the need to study and understand dye-sensitized and perovskite solar cells, not without showing my work to the scientists. I felt the need to get into Carolina Hora's investigation and collaborate with her, but my cover art could never be just another soulless computerized composition solely made as description content. Believing I could make a difference, my role was to present meaningful connections between visual and conceptual, to give and to get, breathing beauty in the opacity of poetry and fiction.

If one is open to learning universal truths side by side with subjective and intrusive thoughts, one will find an immense world of cross paths and millimeters of tension, forgotten minutes and passion-driven unpaid hours; beams of light, inescapable errors, and delusion — in science and art.











Processes, Products and Energy

Dzmitry Ivanou

The world faces increasing energy demand from fast industry and economic growth. The transition from fossil to renewable energy sources has become imperative for human society to reduce greenhouse gases emission to prevent impending climate change. The International Renewable Energy Agency predicts a reduction in CO₂ emissions to 90% by generating electricity using accessible renewable sources such as wind, solar light, geothermal energy, and biomass, to name a few. According to International Energy Outlook (2021), solar photovoltaic (PV) energy can be turned into one of the most shared sources by 2050, surpassing coal and natural gas. Achieving this milestone requires a vigorous pace of innovative PV research with valuable technological advances. It led to the establishment of PV Laboratory inside the Processes, Products and Energy (PPE) group at LEPABE.

The solid growth of PV-orientated research and developments in the PPE, sub-area Energy, started in 2013, benefiting from an Advanced Research Grant awarded to Prof. Mendes by the European Research Council: BI-DSC, Building Integrated Dye-Sensitized Solar Cells. Capitalizing on progress, expansion of knowledge and expertise in PVs, the research interests and scientific production of the PV lab is currently centered on the 3rd generation technologies: Perovskite and Dye-sensitized solar cells, large-scale and efficient water-splitting photoelectrochemical systems for hydrogen and fuel production, chargeable with solar light batteries among other light to energy conversion systems. P. 108–111 Frames from by division and differentiation.

P.112 Residency fieldwork: Dye-sensitized solar cells

(DSSC).

In the scope of the 2SMART project, PPE developed new monolithic solar cells for the conversion of indoor light to power the Internet of Things, low power consuming electronic controllers (e.g., TV, air-conditioning), and as an extension of the battery for tablets and mobile phones, among other promising applications. The PPE group holds several recently published records of light-to-electricity conversion efficiency under natural (outdoor) and artificial (indoor) light conditions of proprietorially developed photovoltaic cells. Presentation and dissemination of scientific and technological outputs in an accessible, visually appealing, and easy-to-understand form is the key to reaching a broader audience beyond the scientific community and raising interest in PV problematics. To promote the application of design thinking in creating innovative strategies to share scientific knowledge and data visualization, 2SMART team addressed this sophisticated challenge by establishing productive collaboration between scientists and artists.

The agreement between i2ADS (FBAUP) and LEPABE (FEUP) set up an artistic residency, hosting in the PPE photovoltaic laboratory the artist Carolina Grilo Santos. She transformed the daily routine of our scientific work into a creative artistic reflection fueled by her own worldview and mirrored in her exhibition: *by division and differentiation*.

Another valuable and tangible product of the artist-in-residence is the creative cover art by Carolina Grilo Santos for the scientific article published in the authoritative journal *ACS Applied Energy Materials*. The cover strikingly differs from the myriads of soulless computer graphics that litter free space where personality must be. The comprehension of the scientific problem, through the artist's reflection, is imprinted in the retina of memory for a long time... bringing readers back to the topic again and again.

ACS APPLIED ENERGY MATERIALS



2022

Volume 5 umber 12 P.115 Cover art by Carolina Grilo Santos for the scientific article published in the journal ACS Applied Energy Materials.











Staring at the Sun Searching Wonder (with Forceps)

Luísa Abreu

Too many questions and hesitant to start.

I stop what I was doing and restart here, like anywhere else.

Fifty-five minutes and fifty-seven seconds were needed for a synthesis and time is as precise as it is irrelevant: over there nothing happens in the present time but in a time yet to come. It is a suspension, a deep breath of a remarkably controlled air.

There and elsewhere, you want to breath spring all year long. Eliminating summer and winter from the environment.

Fifty-five minutes and fifty-seven seconds were needed to look down at the table, at the A4 sheets of paper that were scribbled on. Also lying there, the solar cells: without light. You can stare at them without going blind, the small structures, complex and clumsy, composed by multiple layered materials. They were described by a new lexicon, comprised of acronyms, letters and numbers. Electronic devices capable of transforming solar energy into electricity.

However, is it efficient?

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by division and differentiation, view of the exhibition at the Library of the Faculty of Engineering, University of Porto, 2023.

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Production of the short film by division and differentiation: capture of shooting plan.

P.121 Production of the short film by division and differentiation: capture of shooting plan.

The fifty-five minutes and fifty-seven seconds were but an introduction — you started walking there, but the path is still not set. You don't know where you are heading to. I don't know, I never know. The questions form a system, recalling Gonçalo M Tavares when he recalled Wittgenstein.

All my questions clash with invisibility.

The sun, too big, too far; the cells, too small, too close. That which I come across is a fiction: it's not about that. The machinery, the music, the system, the repetition, the machine, the technology, the mineral, all the matter, the climate-controlled room with the AC set to 23° C, the dance of the researcher that moves back and forth in a methodical ritual. All for that this question remains unanswered, unproven.

We walk a path because we don't know it. And errors stimulate the walker — me, you, and them, in that climate-controlled room at 23° C. Erring systematically, as a method.

(a meeting)





All my answers clash with visibility. Meanwhile, an arm that has no body. Appears: The arm is only a volume, no flesh and bones inside.

Inflated with the purest air through an exhibitionist maneuverer in the middle of the room, with an open and swollen hand in the climate-controlled environment, contaminated and uncontrolled. They never touch, the inner arm and the outer arm, protected by a very thin rubber membrane.

Disappears: The arm is but a shell, a bag with fingers to fit an entire arm, made of flesh and bones. It can be manouvered: the body with the arm is dressed by the arm without body. They become the same. You touch everything, without actually touching anything, protected by a very thin rubber membrane. An ingenious and meticulous choreography of forceps, gloves, and arms.

Appears and disappears, right and left. The strange. The useful.

Each thing in its proper place. Each cell, each light, each lamp, each laser, each shadow.

Tables and tools piled up, objects covered in aluminium foil, protected, hidden, incognito. They are from another order. You need to look for the strangeness and lose the usefulness.

P. 122 Production of the short film *by division and differentiation*: capture of shooting plan.

P. 125 Residency fieldwork.

P. 126–129 Frames from by division and differentiation.

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Production of the short film by division and differentiation: reproduction of a scene with an explanation of the development of solar cells by researcher Jorge Martins. You look down and there is the unknown, that you research on the table, so as not to be startled. You can measure it in metres, unsurprisingly.

You look up because the unknown is uncontrollable and moves around in the crazy air, just for wonder.

The action, the movement. An intent in each gesture.

An anemometer that does not measure the speed of the wind but the intensity of your emotions.

One, two, three, I slowly exhale with you, Carolina. In a perfectly synchronized movement. These words do not have an exact length. I cannot measure our delirium. I cannot weight it. We do not demand clarity from the words, light, shadow, density, weight. It is an unstable place that propels us far, far beyond that room.

Can we research like this? Along the crooked lines? Along wonder?

The glove holds the forceps and I feel you holding the soul. They're minuscule vibrations with enormous consequences that allow you to look without discovering, but always to look.





t light is gold here



















Art ↔ Technology

Miguel Carvalhais & Pedro Amado

The intersection of art and science, art and engineering, or art and technology, has been a familiar trope since the 1960s when collectives such as *E.A.T.* (Experiments in Art and Technology) were formed to promote the collaborative exploration of then-new technologies such as video projection, wireless sound transmission, or robotics, in the contexts of performance art. But since then, these *intersections of art and technology* are often invoked in somewhat unclear terms regarding what they may mean and what their results can be.

Art and technology don't so much intersect as overlap, as we cannot fathom art without technology. To be realised, art demands a medium and hence, technology; art cannot *be* without technology; art is unthinkable without technology.

In spite of this, it is common to find artists, curators, and institutions who elevate the connection of art and technology to being a defining factor of their practices. Most frequently, this means their work is developed through technologies that are less common or that swerve from more familiar and established traditions and thus become more difficult to classify. As the experience with any particular technology develops, it may eventually come to be accepted among *the technologies of art*, a point at which a shift happens in the discourse surrounding it and the emphasis on the technology itself subsides. This happened with photography, film, and video — to point out just a few recent cases — and may happen with more recent computational media, such as video games, large language

P. 134-135

View of Field Theory: Artistic Research in Light, Air and Matter.

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(Des)aceleração, laser-colloid-glass generated image at the exhibition Field Theory: Artistic Research in Light, Air, and Matter, Faculty of Fine Arts, University of Porto. models, and other multimodal generative systems powered by machine learning or many other technologies.

In art and technology collaborations, we can frequently witness the development of two types of dynamics. The first is found when art works as a function of technology, towards technology, and becomes somewhat goal-driven in its aim. This is where we can find commissions with motivations that are squarely grounded in technology and science.

Art -----> Technology

The second is found when technology and science provide resources to art, such as by developing new materials, tools, or methods that artists may use in their work. These can even be developed at the artist's demand, but they may also result from independent research subsequently put at the artist's disposal.

Neither of these constitute true modes of collaboration. Effective collaboration requires outputs that are actual contributions to both fields and where synergies are developed. Are these even possible? Can art and technology cooperate? If so, what can art bring to technology, engineering, and science? Can art produce effective contributions to these fields? The participation of i2ADS in the 2SMART project was steered towards two closely related, albeit guite different, goals. One of these was focused on communication design and communicating science by exploring data visualisation and other media design techniques for the sciences. The communication processes of scientific and engineering teams — those in the 2SMART project, but also a broader sample of the Portuguese science and technology ecosystem — were studied with the goal of understanding their most frequent needs and of devising design patterns that could be used as tools for researchers to deal with design decisions when designers may not be available. This led to direct contributions to scientists' and engineers' design literacy and indirect contributions to a broader scientific literacy. Furthermore, this effort also opened avenues for future research within i2ADS and the Faculty of Fine Arts by disclosing other needs of communication design within the science and engineering teams, namely when design tools are used as part of the research processes themselves and not solely when communication with third parties or broader audiences is needed.

Another goal was focused on art. However, rather than promoting collaborations with science and technology, this aimed to foster artistic creation in a context of science, technologies, and engineering by bringing artists to the laboratories for creative residences. André Rangel in NANO4MED lab, Carolina Grilo Santos in the Processes, Products and Energy group, and Catarina Braga in the Environmental Sciences and Technology group, all laboratories of LEPABE, developed processes of artistic research during which they explored and discovered the spaces of the laboratories, the people that work in them, and the technologies, materials and processes they work with. These residences started without further constraints than a maximum duration and the expectation of showcasing the outcomes in an individual show at the Library of the Faculty of Engineering of the University of Porto. This led to the development of rich experiences that resulted in works that are quite diverse in media, concepts, and approaches, but also in the focus that each artist developed during the residence and in how they resonate with the contexts where they were developed. However, among this diversity, we may discover convergent traits in the works, perhaps because of their shared history or the forces that shaped them.

Each work challenges viewers to see the laboratories and their outputs in a different light, guided by the perspectives brought by the artists. Lasers shine on Petri dishes and reveal complex and colourful structures, hinting at the nano-scale complexity of chemical processes. Natural elements displayed side by side with documentation and research data within a spatial context that feels deeply artificial in a way that constrains the viewer's own proprioception and physical stance. A visit to a laboratory through the lens of a speculative visitor, perhaps a non-human visitor, hints at the beauty and delicacy of scientific research.

With this cycle of residences, we tried to bring the epistemological processes of art to sciences and engineering and to look at the science, technology, and engineering processes through the perspective of art, something that can lead to new critical perspectives and to a reframing and reorganisation process that can only be developed through art. The final show at the gallery of the Museum of the Faculty of Fine Arts of the University of Porto marks the project's conclusion by bringing science and engineering back to the school of art. This show reunites the three works and confronts them in a single space, provoking further dialogue between them and the technologies that brought them to be.

Art ← → Technology

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Views of (Des)aceleração at the exhibition Field Theory: Artistic Research in Light, Air, and Matter.

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Views of HMV_II at the exhibition Field Theory: Artistic Research in Light, Air, and Matter.

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Views of by division and differentiation at the exhibition Field Theory: Artistic Research in Light, Air, and Matter.






























































Field Theory: Artistic Research in Light, Air, and Matter

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Editors: Miguel Carvalhais, Pedro Amado

Texts: André Rangel, Arminda Alves, Carolina Grilo Santos, Catarina Braga, David Lopes,⁵ Dzmitry Ivanou, Gabriela Vaz-Pinheiro,⁵ Joana Loureiro, Lúcia Almeida Matos,⁶ Luísa Abreu,⁵ Miguel Carvalhais, Paulo Luís Almeida, Pedro Amado, Pedro Branco, Sofia Sousa

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Curators: Miguel Carvalhais, Luís Pinto Nunes

Artists: André Rangel, Carolina Grilo Santos, Catarina Braga

Production support: Isabel Gonçalves, Jorge Garcêz

2SMART, engineered smart materials for smart citizens

Project coordinator: Arminda Alves^{1,4}

Project management: Diana Paiva,^{1,4} Inês Romão,^{1,4} José Avelino Silva^{1,4}

Activity 1: Adélio Mendes^{1,4} (team leader), Dzmitry Ivanou,^{1,4} Gabriel Bernardo,^{1,4} Luísa Andrade,^{1,4} Paula Dias,^{1,4} Tânia Lopes^{1,4}

Activity 2: Sofia Vieira de Sousa^{1,4} (team leader), Fernando Gomes Martins,^{1,4} Pedro Branco,^{1,4} Ricardo Santos^{2,4}

Activity 3: Salomé Soares^{2,4} (team leader), Alexandra Rodrigues Pinto,^{3,4} Ana Mafalda Ribeiro,^{2,4} Carla Orge,^{2,4} Fernando Pereira,^{2,4} Joaquim Luís Faria,^{2,4} Joana Vilas Boas,^{2,4} Madalena Dias,^{2,4} Manuel Alves^{3,4}

Activity 4: Maria do Carmo Pereira^{1,4} (team leader), Artur Moreira Pinto,^{1,4} Diana Paiva,^{1,4} Fernão de Magalhães,^{1,4} Filipe Mergulhão,^{1,4} Helena Amaro,^{1,4} Joana Loureiro,^{1,4} Margarida Bastos,^{1,4} Maria João Ramalho,^{1,4} Nuno Azevedo^{1,4}

Activity 5: Miguel Carvalhais⁵ (team leader), Ana Duarte,⁵ Ana Rita Fonseca,⁵ André Rangel,⁵ Carolina Grilo Santos,⁵ Catarina Braga,⁵ Margarida Dourado Dias,⁵ Matilde Ferreira,⁵ Paulo Luís Almeida,⁵ Pedro Amado⁵

Affiliations

 LEPABE – Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

 LSRE-LCM – Laboratory of Separation and Reaction Engineering – Laboratory of Catalysis and Materials, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

3. CEFT – Transport Phenomena Research Center, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

 ALICE – Associate Laboratory in Chemical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

5. i2ADS – Research Institute in Art, Design and Society, Faculty of Fine Arts, University of Porto, Avenida Rodrigues de Freitas, 265, 4049-021 Porto, Portugal

 IHA – Art History Institute, School of Social Sciences and Humanities, NOVA University of Lisbon, Largo da Torre, 2829-516 Caparica, Portugal.

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