



Science and Art for Transdisciplinary Education

A collection of good SciArt education practice

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Executive Summary

Sustainability research has been funded and supported massively by EU's Green Deal policies. Researchers seem to agree that no discipline has the key to a sustainable future, and that a transdisciplinary approach to both research and social transformation are more efficient than multidisciplinary or interdisciplinary approaches. Moreover the understanding is that scientific research for the first time ever has to embrace knowledge from various communities beyond those scientific ones and that whatever technological innovation will be proposed needs to go hand-in-hand with the respective social transformation without which any measure is deemed to fail.

A special position in transdisciplinary knowledge creation is occupied by Science and Art or ArtScience. Combining scientific with artistic research has the potential to enrich science with new insights of ethics and aesthetics and make it more approachable and credible to people, particularly under the aspect of the world-wide populism wave.

SciArt is only now trying to establish itself thanks to some courageous artists and scientists, who practice it and try to train others in it, but it is by far not easy given the centuries long divide between science and art. There is no common language, no standards and very little acknowledgement of the work of artists and scientists engaging in it. Research programs do not dedicate any funds to SciArt/ArtScience work proposals.

Universities have noticed the lack of professionals that can combine and synthesize knowledge from various disciplines and knowledge communities and try to close the gap by offering interdisciplinary courses but they remain rudimentary given the lack of concrete requirements from the industry and the lack of established evaluation methods. Researchers have an easier life if they stay in their disciplinary ivory towers.

This paper shows that Europe already has a lively SciArt community, very much linked with universities and research institutions, which struggles to be acknowledged and funded. The European Bauhaus was key to starting stirring the stagnant waters of scientific research, but more is needed. At the same time new groundbreaking technologies such as quantum and AI do require transdisciplinary thinking to be mastered and scientific journals have started already thinking of how to change their evaluation models to allow for more complex thinking in their publications. The young generation is fully aware of the complexity in which it is immersed and asks for new educational methods and new professions in line with sustainability and wellbeing considerations. Universities still haven't yet figured out how to provide the right skills and knowledge to a demanding and sustainability aware generation Z.

The Community of Practice of SciArt in education has the scope of creating the network, collecting and distributing existing good practice and proposing new ways of learning, work, care and wellbeing for the society of tomorrow.

This report is a collection of good practice as implemented and presented by the various community members during the monthly online recorded workshops. Therefore the name of the presenter is next to each chapter describing the good practice. The chapter on education is a collection of the discussions the community of practice carried out throughout the year.

Science and Art for Transdisciplinary Education

-A collection of good SciArt education practice-

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JRC's Community of Practice for SciArt in education

Background

The Community of Practice for SciArt in education operates in the framework of Joint Research Centre's Science and Art Resonances IV project and kicked off during the summer school of June 2022. With Resonances JRC aims to contaminate scientific practices and findings with artistic research and creative practices, pushing the limits of scientific knowledge whilst enriching policy perspectives and options. The theme of Resonances IV (2022-2024) is Naturarchy. Inspired by the EU's Green Deal, Naturarchy wants to create alternative paths for sustainability knowledge acquisition and policy making beyond the usual evidence-based policy methods adopted so far by the JRC. JRC as well as the European Commission realise that the Green Deal in order to succeed needs not only ferrous rules but also a social and cultural transformation to implement and safeguard these rules. Historically art has been a messenger and a vehicle of societal transformation. The use of SciArt practices in policy making has the potential to augment the messages of the Green Deal and accelerate the vehicle of transformation.

The Summer School 2022 kicked off the collaboration of artists and scientists in the JRC with panel discussions, speeches and presentations around four main topics: decentering the human, techno green, changing the ground and circular Gaia. Such a panel discussion elaborated the subject of SciArt in education. Panelists were Michael Hoch, Peter Purg, Stephane Chaudron, Tremeur Denigot and representatives of the Pizzigoni school of Milan.

The minutes of this panel discussion can be found in the Annex.

The Community and its work in 2023

The Community of Practice was launched officially in January 2023 with Naouma Kourtj, a senior scientific officer in JRC of Ispra with an engineering background, as facilitator. The Mission of the CoP is:

To foster trans-disciplinarity in middle and higher education by collecting, developing and sharing good Art&Science&Humanities practices

The aims include:

- To introduce SciArt practices in middle and higher education
- To embrace complexity and unpredictability in education as opposed to determinism and reductionism
- To allow for spaces of trial, co-development and transformation in the educational system and to welcome failure and error as means of surprise and opportunities of learning
- To embed diversity, responsibility and interdependencies in future technologies including attention for disabled and the non-human
- To cherish Nature's ways of generating and sustaining life

Members are:

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Sofia Greaves	University of Vigo
Tatiana Chemi	Aalborg University
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The Community of Practice (CoP) met 9 times in 2023 as follows:

Date	Speaker	Title
17/01/2023	Amanda Jane Ozin-Hofsjaess	Art Science Vision
21/02/2023	Piero Dominici	Beyond Black Swans /Complexity
24/04/2023	Robin van der Akker Anita McKeown	Transdisciplinary Studies in The Netherlands Muirin Catalyst Sustainable STEAM
18/05/2023	Tatiana Chemi Chiara Paolino	Artist led learning Innovative Business with Arts
15/06/2023	Sofia Greaves	Postgrowth
17/07/2023	Maria Fernanda Rollo Clara Sarmento	Presentation of the COST- SHIFT project Transdisciplinary Studies in Porto Polytechnic University
27/09/2023	Victoria Vesna	Re-framing STEAM
18/10/2023	Kristin Bergaust	Interdisciplinary courses in Oslo Met University
15/11/2023	Tam Nguyen	Transdisciplinary Insights Honours Program KU Leuven

The meetings served to get to know each other, to learn about each other's work, to share good practices, to discuss the purpose and objectives of the CoP, to create a space for SciArt transdisciplinary practices and knowledge exchange. All meetings were held online. This report summarises all above presentations.

In extensive discussions during the meetings the CoP set itself the following objectives:

Educational	A collection of Methods & Pedagogies for transdisciplinarity Proposals for new Transdisciplinary Courses Rethinking Education A Handbook for transdisciplinary practices
Academic	A transdisciplinary journal Accessible and Open Publications Transdisciplinary epistemologies
Crosscutting	EU funding Recruiting members
New Tools	Space for critical thinking, experimentation and failure A time machine to appreciate the present A SciArt encyclopedia
Profiling	Branding Communication and Dissemination Getting to know each other Platforms Wikis

The CoP is fully aware that the above objectives are too ambitious, since there is no budget associated with it. Therefore, exploring future funding possibilities is crucial for delivering on the objectives.

In the meeting of 17 July 2023 the CoP invited the coordinator of the Cost- SHIFT project, Fernanda Rollo, to learn more about the objectives and working methods of the project and to assess possibilities of collaboration and funding. SHIFT stands for Social Sciences and Humanities for Transformation and Climate Resilience, and it has 4 work packages, with the 3rd being the most suitable to host the activities of the CoP. The presentation had as result that some CoP members joined SHIFT and some SHIFT members joined the CoP. We expect this collaboration to be strengthened in the future with more common activities and deliverables. The collaboration with project SHIFT may facilitate achieving some of the above objectives. Other opportunities based on Erasmus+, Horizon Europe and other EU funds will be explored in 2024.

In the next chapters we shall go into more details of the presentations and discussions undertaken in the meetings of the CoP over the year 2023, as well as take stock of the Naturarchy summer school 2022 presentations.

The need for transdisciplinarity

We undergo a period of profound shifts, permanent crisis and mistrust to institutions. Science that underpinned the economic boom after the second world war fails to deliver in the 21st century. The changes will affect everybody's life, whether we are conscious of them or not. Departing from our compartmentalized and disciplinary scientific knowledge patterns and working methods seems one way out of the pre-announced doom due to climate change. Transdisciplinarity is needed now more than in any other time in history.

What is transdisciplinarity

Transdisciplinarity is a term coined already back in the 70s, which has recently gained in importance in the current quest for solutions to our planet's wicked problems, such as climate change [1], loss of biodiversity [2], increase of inequality and poverty [3] etc. Transdisciplinary education and research are believed to offer ways to counteract the problems that a strict discipline-based science and technology is being held responsible for their creation in the first place.

But what is transdisciplinarity and how does it differ from multidisciplinary and interdisciplinarity? An analysis offered by Lawrence [4] stating that in multidisciplinary disciplines may collaborate but do not cross their respective boundaries. In Interdisciplinarity disciplines are in much closer interaction, exchanging methods and tools to the extent that new disciplines may arise. Transdisciplinarity is said to go beyond, acknowledging the unity of knowledge and involving even social actors in the generation of new knowledge [5].

One interesting definition of Interdisciplinarity is the one in the Encyclopedia of World Problems and Human Potential that stretches also the individual aspect of inter- and transdisciplinarity:

It (Interdisciplinarity) is basically a mental outlook which combines curiosity with open-mindedness and a spirit of adventure and discovery. It includes the intuition that relationships exist among all things which escape current observation and that there are analogies of behavior or structure that are perhaps isomorphic. It is not learnt, it is practiced as a form of continual training and systematically working towards more flexible patterns. [UAI][6]

Scholars may distinguish between interdisciplinarity/transdisciplinarity in Research [4], in Innovation [7] and in Education [8]. While the first two draw techniques from collaborative design to complex system analysis, etc., the latter has been mostly practiced through the so-called STEM (Science, Technology, Engineering and Mathematics) or more recently STEAM (Science, Technology, Engineering, Arts and Mathematics) education and it bases itself in the convergence of disciplines while teaching.

As Cockburn [9] writes;

Transdisciplinarity is therefore about transcending two significant boundaries which limit the potential of research to meaningfully address complex sustainability challenges. First, it transcends the boundary between societal and academic actors and their respective knowledge systems. Second, it transcends the boundaries between disciplines which have resulted from the Cartesian-Newtonian paradigm which dominates science...

It seems to be widely understood that transdisciplinarity is better suitable to trigger the social transformation needed to tackle sustainability, since it operates on the science-action nexus [10].

This Community of Practice (CoP) thinks that the nexus of transformation is on science-art-action and aspires to introduce arts as an element at the same caliber of science in every action. Art can inspire change in people and we have many examples of such art pieces in the history of art. The sustainability battle can only be won, if cultures will change. The combination of Science and Art is a very potent form of inter/transdisciplinarity that has the potential to shift perceptions and change society.

EU's Sustainability Program

The EU's Sustainability Policy package tries to be both holistic and generous. It ranges from policies to tackle emissions and to decouple the economy from fossil fuels¹, to protecting biodiversity², to fostering the circular economy³, to corporate environmental reporting obligations⁴ all the way down to sustainable investment⁵.

The EU has made its Green Deal the heart of its policies and has taken the boldest action worldwide to combat climate change. One third of the €1.8 trillion investments from the Next Generation EU Recovery Plan, and the EU's seven-year budget will finance the European Green Deal⁶.

Similarly, Horizon Europe, the EU framework for research, earmarked 35% out of its 95.5 billion euro to climate change research. In October 2023 Erasmus+ encompassed 3.310 ongoing projects related to green skills, environment and climate change⁷.

Notably culture is the most prominent factor in the New European Bauhaus, which aims to build a sustainable and inclusive future *"that is beautiful for our eyes, minds, and souls"* and which in the period 2021-2022 had a budget of 85 million euro⁸.

Transdisciplinary research communities, academia, industry, SMEs, national and regional actors and citizens have been involved in the race that should lead to a societal transformation that can sustain an emissions free Europe by 2050. An example is the Transformative Power Lab, funded by Horizon Europe, which aims to foster knowledge development and facilitate an interdisciplinary and transdisciplinary exchange on power dynamics to accelerate societal change by equipping participants (practitioners, policy workers and researchers) with a better understanding of power by making it visible and tangible, as well as to create a motivation to apply these insights to their work and strategies [11].

Acknowledging Complexity

Talk by Piero Dominici

In our hyper-technological and hyper-connected civilisation the challenge is to inhabit complexity instead of trying to reduce it to manage it. Complexity is not only a matter of academic research but of major interest for our societies and democracies. A great deal of work has been dedicated in the

¹ https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

² https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

³ https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

⁴ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464>

⁵ https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance/platform-sustainable-finance_en

⁶ https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

⁷ <https://erasmus-plus.ec.europa.eu/projects>

⁸ https://new-european-bauhaus.europa.eu/index_en

last years to predict the so-called “black swans”, however these are only an expression of the complexity in which we inhabit. Our societies need to go beyond “black swans” [12] and accept emergencies as a form of emergence [13] which is the spontaneous, uncontrollable self-organisation of life.

The idea of managing complexity is a contradiction in itself. We need to accept emergencies as an integral part of emergence, which is the spontaneous, uncontrollable, unpredictable self-organisation of life. Complexity as a feature of life requires a wide range of abilities and epistemologies and approach to education. Complexity is often confused with complication, but in reality, they are two different and distinct concepts. Complicated systems can be broken down to their parts and put back together but the sum of the components is equal to the whole. On the contrary, when we put together complex systems we find that the whole is greater, richer and more varied than the sum of the parts. Moreover, complex systems are capable of self-organisation, new interactions and new dynamic behaviors, in short they are capable of emergence. They are not subject to control and they cannot be managed or predicted [14]. Our teaching and learning methods of isolating the parts of the system in order to know about them do not work since it is exactly the connections that make the difference. Complex systems are not observable in every direction therefore not measurable. More than everything there is no such thing as an external observer, since the observer is fully connected to and interlinked with what she tries to observe in a way that the mere act of observing impacts the subject of observation.

The primary function of education should be to understand the connections and interlinkages, recognise them and even create new ones [15]. Moreover, the educational system has to get rid of all false dichotomies such as nature and culture, human and technological, knowledge and skills etc. In fact, the terms of multi, inter and transdisciplinarity are results of such dichotomies. Academics are requested to work more transdisciplinary but in practice their careers are hampered if they do so.

False dichotomies such as humanities and sciences, technology and culture, etc and logics of separation and the confinement of knowledge within borders has to be abandoned. One might think that in this hyper-technological society we live in, only technical and digital skills are necessary, but the big challenges of today require far more than reductionist and deterministic methods of thinking and working [16]. Failing to see that technology is part of our culture and not something external creates more inequalities and asymmetries in our society, as we saw it happening during the pandemic. Data cannot tell much of qualitative factors and it cannot capture our interconnections and interdependencies. The qualitative factor is what motivates humans to go beyond the rational and the useful.

Similarly, our democracies make the mistake of seeking concreteness, simplification, predictability and elimination of error instead of acknowledging the complexity in which we are merged [17].

We must educate hybrid figures who are not experts of everything, but who can hold together creativity and methodology, humanities and technology, imagination and reality so as our society works as living organisms and not as mechanisms.

New Technologies (AI, Quantum)

The advent of quantum

Since the time of the double slit experiment physicists and philosophers struggle to understand the impact of this experiment on what we call reality⁹. The collapse of the wave function when the measurement equipment detects the particle has provoked a completely new thinking about what we think is real and measurable. The claim that this collapse is only relevant for small particles did not satisfy the scholars, who carry out the experiment with always bigger particles. Reality seems to emerge out of measurements including our own human senses. If so, is there a human consciousness and what is it? ¹⁰

J. Bell says

to restrict quantum mechanics to be exclusively about piddling laboratory operations is to betray the great enterprise. A serious formulation will not exclude the big world outside the laboratory. [18]

Karen Barad in her agential realism talks extensively about the inseparability of the observer from the observed. “A measurement is a correlation or entanglement between component parts of the phenomenon, between the measured object and the measuring device”. She reiterates “I am interested in a post-human understanding that does not presume the human to be a special system separate from the natural processes that he or she observes, but rather one that seeks to understand the emergence of the human along with all other physical systems.” [19]

The uncertainty principle is another fundamental quantum mechanics concept that adds to the new way to see reality. According to it we cannot know both location and momentum of a particle with certainty, which adds to the appreciation that complex systems are not to be observed and determined in all dimensions.

Superposition and entanglement, quantum tunneling, and the uncertainty principle are more than just the physics of small particles. They redefine the relation of the human with nature, they decentralise the human and push us to think in terms of interconnections and interdependencies among ourselves and with nature. They are potent messages for a whole new way of being and for this reason they should be taught early in school [19].

In 2018, the EU launched its Quantum Flagship, a large-scale research and innovation initiative to consolidate and expand European scientific leadership and excellence in this research area, to kick-start a competitive European industry in Quantum Technologies and to make Europe a dynamic and attractive region for innovative research, business and investments in this field ¹¹.

Many artists together with scientists work to divulge these messages in platforms such as Quantumart¹² or Quantum-Art-Jam¹³. In Nature article “The Future is Quantum” Sophia Chen [20] claims that “the quantum-tech industry will need workers with various educational backgrounds to benefit society” and describes the launch of many quantum engineering undergraduate courses. To

⁹ <https://www.science.org/content/article/quantum-experiment-space-confirms-reality-what-you-make-it-0>

¹⁰ <https://blogs.scientificamerican.com/observations/what-does-quantum-theory-actually-tell-us-about-reality/>

¹¹ <https://qt.eu/about-quantum-flagship/>

¹² <https://www.iamaq.org/what-is-quantum-art>

¹³ <https://www.aalto.fi/en/events/quantum-art-jam>

really benefit society though quantum studies must become transdisciplinary and include the arts. Projects funded by the Quantum flagship should consider collaboration with artists who can help convey the latest findings of quantum physics.

Transdisciplinarity through AI

Artificial Intelligence (AI) and Data Sciences (DS) are increasingly transdisciplinary [21]. Their power lies in the number and variety of sources from which it pools knowledge to learn, train, compose outcomes to support decision making processes. It would make little sense to constrain AI's ability to one discipline or even a group of those, then the more knowledge it collects the more options it delivers. This poses problems in both upstream and downstream the use of AI-related tools.

Upstream one must properly evaluate, select and weigh the sources from which AI pools data and information. This requires expertise in a variety of fields, capability to extrapolate, mediate and generalize as well as capability to create connections and interdependencies.

Downstream AI may bring answers and results that will impact a variety of actors from different backgrounds and with different professional and private stakes. How these AI answers will be evaluated and implemented require people with a transdisciplinary background so as to make good use of them. The secondary users of AI tools must be able to measure the biases of their input data and obtain results, which can be done only if they are both aware of potential problems and if they have the necessary tools readily available. Here the question of independent authorities comes in to regularly audit the AI products around us. Companies and AI product developers must be capable of "opening the black box" and clearly exposing the monitoring they perform over an algorithm. [22]

But AI has gone even further. It is by far not only a tool for knowledge synthesis and decision-making support. Longbing Cao [21] claims that transdisciplinary AI/DS systems involve systematic integration, deep interaction, fusion and transformation and new conceptualization of constituent disciplinary thinking and approaches.

AI tools such as ChatGPT, DALL-E 2, Discord, Midjourney, etc. have the great potential to wake up the scientist or the artist inside every single person and contribute therefore to individual transdisciplinarity and new forms of learning [23], which may have both beneficial and therapeutic impact on society.

The EU was the first worldwide to take the bold step of regulating AI through its AI act. This act prohibits unacceptable risk and mostly regulates high-risk AI systems. As unacceptable risk it classifies AI systems that deploy subliminal, manipulative, or deceptive techniques, exploit vulnerabilities, compile facial recognition databases, etc. ¹⁴. Still very few people in Europe know about and even less understand the implications of the EU AI Act. Engaging artists to convey the messages of this pioneering regulation would benefit everyone.

Researching the potential for arts and science collaborations to lead us to futures beyond capitalism by Sofia Greaves

The post-growth movement argues that economic growth is destroying the planet and not only humans and that there can be a plurality of diverse ways to redefine economic prosperity. There is the unfounded perception that economic growth benefits everyone with more jobs and money.

¹⁴ <https://artificialintelligenceact.eu/high-level-summary/>

Instead, the opposite is true; growth is concentrated in the top layers of the society. No-growth does not and must not automatically mean less jobs.

EU suggests a middle path between Growth and Post Growth, called Beyond Growth that argues that “economic growth centered on fossil fuels is simply obsolete”¹⁵.

Durrant D. et. al. [24] argue that the only available experience of reductions in economic growth has been in recessions and their inequitable consequences. We would challenge the idea that a critique of growth implies a forced recession. We argue it allows scope for different forms of urban development and different types of economic activities, possibly even a greater scope for types of low impact activity than under current circumstances. In contrast to an unplanned recession, a planned restructuring of economic activity – through a focus on environmental and spatial change – would require the use, the re-purposing, or adaptation of many of the instruments and tools planners currently have at their disposal.

The limits to growth argument emerged in the ‘70’s after a work commissioned by the Club of Rome [25]. According to the report all economic activity is based on natural resources converted to energy, converted to capital. An increase of GDP means an increase in the extraction of natural resources and is limited by nature’s capability to renew these resources. This conclusion was heavily contested back then but has been confirmed many times by models and scientists since then.

However, technological innovation has created the illusion that we can continue growing beyond the obvious limits of natural resources. Solutions such as the circular economy are based on increased efficiency, which leads to more natural resource extraction. New technologies, such as CDR (Carbon Dioxide Removal) imply that we have to create more Carbon Dioxide to make them economically viable.

The post-growth idea of innovation is that “Technology is not neutral but rather acts as an instrument for the creation or destruction of social and cultural orders.” Since innovation is understood as production of technology that generates profit it is bound with the logic of economic growth. On the contrary, untangling innovation from growth is key to imagining a post-growth era [26].

The Post-Growth Innovation Lab, funded by the European Research Council, is an international, transdisciplinary research group which, broadly speaking, conducts research on the ways in which notions of science, technology and innovation can support the transition towards a post-growth society¹⁶. They focus on how to produce innovation in more appropriate and responsible ways and want to answer the question of what science, technology and innovation would look like in a world not driven by the endless pursuit of economic growth but based upon the assumption of unpredictability, incomplete control and a plurality of legitimate perspectives, while contesting the hierarchies between scientists and artists and between disciplines. Combining science and art can create new ways of inquiry that take us past the imagination of two separate disciplines.

¹⁵ <https://www.beyond-growth-2023.eu/>

¹⁶ <https://easst.net/easst-review/403/post-growth-innovation-lab-science-technology-and-innovation-in-a-post-growth-society/>



1 Ocean Connections by Kristin Bergaust

The SciArt movement

SciArt or ArtScience is not new. The aim is to go beyond the dichotomy of either Art or Science and to approach investigation, observation and creativity as a whole, with a variety of expressive possibilities. The merging of art and science can be achieved in various ways. There are individuals who naturally can move well in both disciplines, but they were not trained to, since education is mainly disciplinary. It looks like a great number of Nobel laureates have practiced some sort of art, as Root-Bernstein R. et. al. suggest in their paper [27]. On the other hand, in SciArt/ArtScience has the role to bring together people from different disciplines within the scope of co-creating, be it in design or in the development of technology, or even in adopting new ways of thinking about the world, or producing art with the use of science and technology.

During the one year of the work of the Community of Practice, we have focused mainly on education, mostly secondary and tertiary, but we also touched upon other fields such as scientific research, lifelong learning and business.

What is SciArt

There is no standard definition for SciArt or ArtScience. It seems that many names exist according to how the practice of bringing together scientists and artists is perceived and carried out and who sets this process in action [28]. It is not clear if there is a difference between SciArt and ArtScience. Sometimes the terms mark the initiation process, ie. if scientists seek the support of arts mainly for communication purposes or if science is invoked by artists for inspiration.

We can safely state that it is an interdisciplinary movement to bring scientists and artists together with the scope to break disciplinary boundaries, boost inspiration and creativity and propose new, more sustainable and socially robust worldviews and realities.

Some say that SciArt goes back to Leonardo Da Vinci, but we can easily argue that it goes back as far as the construction of Parthenon in classic Athens for which architecture was coupled with aesthetics or to cave painting when hominids processed pigments for aesthetic purposes. To serve society is in many ways the first mission of art and science. It is indeed what made the two appear inseparable for most of human history [29].

It is only in the 20th century that Art and Science became strictly different disciplines, meaning that if one is the first, it cannot be the second and vice versa.

Practicing as well as appreciating art has proven to promote self-understanding and transformation along with other-understanding and increase in empathy. Such skills do not make up part of a scientist's or an engineer's education, who often see SciArt only as a way to communicate their science. On the other hand, analytical thinking does not make part of the artists' training, who often see scientists as technicians for their artworks. Moreover, ArtSci goes beyond artists inspired by scientific results that they can interpret artistically in isolation. Both SciArt and ArtSci means a process in which scientists and artists are engaged throughout the whole process of creation of a piece of scientific innovation or an artwork, but most importantly they carry out research together by combining creativity with scientific rigor after they have posed a common question.

Sustainability scientists often stretch the role of arts in sustainability transformations, however there is still little evidence of scientific research undertaken in collaboration with artists.

By turning sustainability issues more experiential and concrete, and offering alternative means of communication, the arts offer diverse entry points for people and the possibility to connect

cognitive with tacit and affective domains of knowledge, offering a deeper intuitive awareness, while also overcoming the 'hegemony of the text' commonly dominating academic production [30]

Most of the CoP Members either are themselves art practitioners, or are in collaboration with artists. They strive to merge art and sciences in their work. Working at the edge of science and arts with the aim to unite the two is challenging and there is little experience of how to do it. Therefore, the members of the CoP strongly feel the need to exchange practices and learn from each other.

SciArt in education

At the latest in high-school education we come in contact with disciplines and we experience the artificial divide between arts and sciences. The claim is that this prepares us better for a university education during which we are forced to choose what we want to do in our professional lives from a young age. However, given our significantly longer lifespans, choosing at such a young age may be counterproductive for our societies and our well-being. Moreover Braund M. & Reiss M. in their article "The 'Great Divide': How the Arts Contribute to Science and Science Education" (2019) state science teaching and learning are not complete without the arts and that:

Today's and tomorrow's citizens need both the arts and sciences to equip them with the criticality and creativity of mind and the aesthetic and emotional capacities essential for being rounded and cognate humans [31]

Both academic education and professional growth should be available for those who don't want to choose; or for those who want to try different directions before they commit to something concrete. Inter- and transdisciplinary education should become more readily available and accessible.

SciArt/ArtSci have been already introduced in academic education creating positive impact. These efforts, however, remain isolated and limited and in desperate search for funds. This Community of practice has the aim to increase the body of knowledge in SciArt for education and create a momentum that will help to attract funds.

SciArt in secondary education

Muinín Catalyst Sustainable STEAM (MCSS) by Anita McKeown¹⁷

Anita was trained as an artist almost 30 years ago. She mostly worked in situated and socially engaged practices and has been an environmental activist. She is also a researcher and educator affiliated with SmartLab.

Muinín catalyst sustainable STEAM program initially devised for 15 – 16 years, however is now being applied across post-primary, with learners 11-18 years old. Ireland offers the unique opportunity of a transition year, without curriculum. Through a series of research projects (2018 – current) the team have worked with ~1700 learners to understand how they learned, what they liked to learn, where they found learning gaps and applied reverse engineering to give feedback to the teachers so as to improve their programs. They worked with a cohort of 75 students in a full academic year, which they saw 3 times per week for 1 hour and 20 minutes to co-design resources and evaluate their learning. It is noticeable that 91% of that cohort felt they didn't have any future¹⁸. Climate change and the VUCA (Volatility, Uncertainty, Complexity and Ambiguity) world were of major concern.

¹⁷ <https://www.muinincatalyst.com/>

¹⁸ https://www.epa.ie/publications/research/epa-research-2030-reports/Research_Report_409.pdf

The practices used by Anita's team were Permaculture Resilience Praxis, Inclusive Design, Circular Design Thinking. Muinín in Irish means trust and is a key underpinning of MCSS - to build trust in the process of an integrated literacies approach to learning - This links back into the aspect of the OECD findings and the needing to see processes that can be trusted but it also is about building trust in the young people that they can create their future and have the confidence and competencies to do so. One of the most important activities they apply is the design sprint, which runs for 5 days. The questions are co-devised with the students. The transdisciplinary design lab shows the students that 80% of mitigation occurs in the design phase. This is an empowering way to change the future.

The Irish current education system gives the impression to students that there is a right answer, whilst systems thinking shows us that a right answer does not exist because problems are wicked, and answers are complex. The design sprint helps students understand this complexity by getting into ideation and prototyping. These are foundational skills usually not exercised in schools. The team also uses reflection practices to iterate with the students and get the modules better for future users.

In the Irish education system, secondary school students are used to being told the information and they are less good at putting the information to use. In Muinin catalyst sustainable STEAM program students train skills such as time management, taking responsibility for planning and scheduling and self-managing their activities. They also learn how to make their games relevant and interesting for their peers and to develop them for a scope, which is different from their own entertainment. The learning environment is fun, and students report that the design sprint allows them to connect to their own feelings of fear, insecurity and awareness.

Out of the sprint on climate-change-game design module, the team of Anita developed a whole unit of activities of 33 one-hour lessons that any teacher can deliver. They also deliver online resources for the teachers that have been verified by the research team. The units of learning have modules that can be used independently.

The project currently is working with 16 schools, but they look forward to working with others. The programs were included in the top 100 teaching solutions in an initiative launched at COP28.

Concerning the role of the senses, high importance is given to listening to the local reality, and then discussing what are the five senses of the local situation. The 5 senses enter also in the work of social emotional learning where trauma informed practices become important. The school's linear and silo learning makes it difficult to do any sensorial work. To this end the team have also worked with experts to develop and launch an eco-anxiety module integrating both social emotional learning integrating approaches and the increasing evidence within neuroscience on the impact of trauma / insecurity. This is to support teachers to support learners' increasing anxiety in this area.

The Irish School Senior Cycle curriculum has recently undergone an assessment and it was found not fit for purpose¹⁹. The OECD gave its opinion to the assessment and also agreed that the educational curriculum is not fit for purpose²⁰. Many groups engage in developing curricula, but it is not easy to bring a change. The Advisory Report proposed an approach towards the redevelopment of the senior cycle, with a clear purpose, vision and principles in mind and with priorities, a sequence of work and next steps outlined. Anita's team collects the evidence on the ground (McKeown et al 2022) needed to persuade the policy makers to induce the change that moves away from teaching

¹⁹ https://ncca.ie/media/5399/scr-advisory-report_en.pdf

²⁰ <https://www.oecd.org/ireland/education-in-ireland-636bc6c1-en.htm>

curriculum to facilitating learning relevant and appropriate for the VUCA world and adaptation to the urgency and reality of Climate Change (McKeown et al pending 2024) . This would include not just an awareness of the facts about climate science, but also how to apply the knowledge using a circular ethos and integrated literacies. Such a change would require to re-train every post-primary teacher in Ireland and an assessment process that integrates appropriate competencies for the world these young people will have to adapt to.

Education for Climate Coalition²¹

The Education for Climate Coalition is the European participatory community to support teaching and learning for the green transition and sustainable development.

The Education for Climate Coalition wants to inspire, develop and draw on innovative European education capabilities. The priorities are to train teachers, bridge education with science, develop green skills and competences, raise awareness and change behaviors.

For this, the Education for Climate Coalition aspires to create a community led by students and teachers with their schools and networks and other educational actors, learn from as many relevant experiences as possible, bridge fragmentation between education sectors, domains and people.

The Education for Climate Coalition is meant to gather the whole education community in the EU, although it mostly connects to school education. It is a platform on which one can find resources and people are concerned with sustainability.

It is crucial to build skills and competences to live and work more sustainably. The European Commission has developed a sustainability competence framework (GreenComp)²², to help learners and educators form knowledge, skills and attitudes towards a fairer, greener economy and society.

Cultural Collision by Michael Hoch

Cultural Collisions address both university students and secondary education students. Cultural Collisions is a SciArt project proposed by Michael Hoch and inspired by his SciArt program in CERN. It came out of the conviction that today's children need to explore their talents and develop skills to be ready for the challenges of the 21st century [32].

Cultural Collisions in the Technische Universität Vienna is a multidisciplinary project that kicked off in September 2022 and is expected to run for four years in annual cycles. In every cycle the project will include more partners and more disciplines. The theme is Climate Change and will have a different focus in every cycle.

In the academic year 2022-2023 the project included only the faculty of architecture. Architecture students are trained in exhibiting their works, which goes beyond presenting it, and are best candidates for SciArt transdisciplinary projects that include the arts.²³ The students were asked to work in teams and develop their ideas around Urban Planning, which resulted in an exhibition for school children by the end of January. Schools visited the exhibition and then inspired by this experience, prepared their own SciArt projects. After January the exhibition moved to the TMW (Technisches Museum Wien), which led the school projects. During this phase TMW held workshops

²¹ <https://education-for-climate.ec.europa.eu/community/about>.

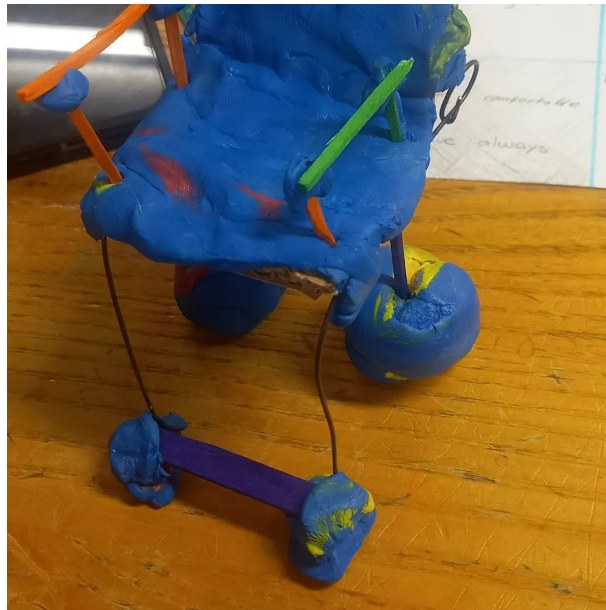
²² https://joint-research-centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en

²³ <https://tiss.tuwien.ac.at/course/courseDetails.xhtml?dswid=7657&dsrid=981&courseNr=280A15&semester=2022W>

and other exhibitions for the school children to support the development of the school projects. This phase culminated with an exhibition of the school projects in the TMW.

In September 2023 the whole cycle was launched again, this time with more engineering disciplines and more students.

The specificity of the project is that starting in academia, it spreads to secondary education and involves future students. Moreover, it tries to prepare students for the problems of climate change by hands-on work on their own solutions while introducing them to transdisciplinarity and using art as a method of communication and presentation.



1 prototype chair design for empathy training Muinin Catalyst

SciArt in Academia

Delta Studies by Robin Van Den Akker

The term Delta studies points to a collaboration between two art academies and a university, the Erasmus University of the Netherlands. The result of this collaboration is the Lab for Arts, Sciences and Society (RASL)²⁴ dedicated to transdisciplinary studies. The RASL was set up 5-6 years ago with the mission to transform society through the arts and sciences. One of the lab's aims is a horizontal approach to knowledge creation. The RASL education program is transformative, transdisciplinary and responsible. It aims to provide an environment where young people can grow into something that they can define for themselves. RASL offers an optional dual degree. This is an arts bachelor and a university bachelor that can be concluded in 5 years instead of 7 if the courses had been taken separately. The reduction over the years is possible through the exchange of competencies. RASL also offers a minor program, a PhD and a transdisciplinary summer school²⁵. A unique arts sciences master will be launched in 2023 in which the classes from arts and sciences are mixed. An arts sciences bachelor is by far more challenging, and it is under preparation.

Delta studies [33] are situated in the Delta of Rotterdam, where local and global concerns play out, they blur, “compose” in the sense of Latour [34] or “compost” in the sense of Haraway [35] with arts and sciences. RASL uses the methodology “provisional pedagogies”, which needs continuous reflection and adaptation. It is called provisional, because one cannot know what the outcome of the project work will be and because one doesn't know exactly how to get there a-priori. The path is re-invented continuously through interactions with the students.

The master's degree is both project based and research based and investigates questions set by the societal partners. An example is last year's topic on “water” provided by the municipality of Rotterdam. The students involved many societal partners themselves, who brought in their perspective. They worked together and came up with many ideas and products that one could not foresee in advance, such as a policy document, a theater, an installation, a game etc.

The dual degree is a selective course for students who do not want to choose between arts and sciences. Students are usually enthusiastic for such transdisciplinary courses.

Transdisciplinary Studies in Porto Polytechnic University by Clara Sarmento²⁶

The Centre for intercultural studies (CEI) of the Porto Polytechnic University (ISCAP-P.PORTO) has three research lines: Intercultural Theories and Practices, Intercultural Communication and Intercultural Studies in Business. Clara Sarmento is the coordinator of the centre.

The three guidelines relevant for the work of the CoP are:

1. Interculturality, understood as movement, communication, dynamics, encounter, synthesis, with actual effects in science, education business and society
2. Intercultural competence, understood as effective communication, mutual intelligibility, sharing of alternative concepts and epistemologies
3. Culture, as an asset for higher education, business, science and development

²⁴ <https://www.eur.nl/en/esphil/research/research-themes-and-projects/comenius-leadership-fellow-grant>

²⁵ <https://rasl.nu/event/rasl-summer-studio-2023/>

²⁶ <https://www.iscap.pt/cei/en/home-en/>

Interculturality is a way to avoid the commonplace notion of the intercultural as a mere “us versus them”. “Intercultural” functions as a sort of third space [36], a third space for hybridity, subversion and transgression.

Intercultural competence becomes the place where the overlapping of cultures occurs, which is the characteristic of a site of cultural translation. Cultural translation is a major force of contemporary democracy also in the academic field.

The center has published over 20 books in national and international editions, numerous papers and has organized over 200 conferences and workshops on this subject, along with master classes and seminars. In the last 12 years they have been publishing the online SCOPUS indexed journal “E-REI, E-Journal of intercultural studies.

In the book “Cultural Tourism and Heritage in northern Portugal” [37] an interdisciplinary approach was taken that combines Law, Politics, Anthropology, Artificial Intelligence, Art, Business whilst it tries to show that an intercultural approach doesn’t favor only business but also archeology, maritime history, visual arts, tourism, law studies and heritage among others.

Intercultural studies can be an asset for research. Research programs often fund such studies and CEI participates in three COST²⁷ actions and three Erasmus+²⁸ projects all promoting transdisciplinarity.

The project TheRoute²⁹ (Tourism and Heritage Routes including Ambient Intelligence with Visitants' Profile Adaptation and Context Awareness) aims to conduct studies, research and experimentation around the challenge of automatic generation of routes for visitors by using ambient intelligence and artificial intelligence. The project is carried out at the Polytechnic of Porto Engineering Department and the Centre for Intercultural Studies helped create routes of art, heritage and literature.

In the project SciArt-Promoting 21st Century skills through an inclusive STEAM approach to cultural heritage³⁰, the team investigates how heritage contributes to the formation of a common European identity visible in both local and transnational level. This is being investigated based on three historic artefacts: Roman coins thought of as ancestors of the Euro, ship building materials and techniques and boats paintings. This project is a strong example of combining science and art.

The project StreetArtCEI³¹ is a virtual museum and digital archive of street art works in Porto and Northern Portugal, which already contains more than 5000 images in permanent update. This project has attracted the attention of social media, radio and television. It has brought a lot of visibility to the institution, and it has received awards for social impact. StreetArtCEI is an intercultural project, which takes place in a border zone between the legal and the illegal, where researchers play the role of mediators, crossing discursive fields in permanent intersection. This project is an intercultural communication between marginal and dominant, young and adult, academic and popular cultures and proves that stakeholders can profit through transdisciplinarity.

Finally, ISCAP-P. PORTO offers the master’s degree in intercultural studies for business fully taught in English with 45 posts annually. It opened in 2016 and was reaccredited in 2022. This is an

²⁷ <https://www.iscap.pt/cei/en/cost-european-cooperation-in-science-and-technology-2/>

²⁸ <https://www.iscap.pt/cei/en/projects/>

²⁹ <https://www.gecad.isep.ipp.pt/theroute/>

³⁰ <https://sci-art.eu/>

³¹ <https://streetartcei.com/>

intercultural and interdisciplinary master's course that combines inputs from business and cultural studies, the arts, politics, information technologies, tourism and languages among others.

The institute also offers post-graduate studies in science-based entrepreneurship and in intercultural mediation with the aim to connect scientific projects with business useful for society.

Re-framing STEM by Victoria Vesna

Victoria Vesna founded the ArtScience Centre of UCLA³² in 2005, when ArtScience was still unknown to most. Victoria was inspired by the ideas of Buckminster Fuller that kids are born as comprehensive and interdisciplinary thinkers but education pulls them into the needs of the industrial age. Fuller's hope was that new technologies would cancel the gap between disciplines but that proved more difficult than thought.

Victoria created the center in two different locations of UCLA. While the center is on the north side of the campus the exhibition space is on the south side, in the institute for nanotechnologies, a good 15 minutes walk away. This is on purpose to not isolate the arts from the sciences.

At the beginning there was no agenda, people just met and exchanged ideas. This resulted in common projects out of friendship.

Throughout her work Victoria thought that STEM (Science, Technology, Engineering and Mathematics) education missed the arts and felt like a plant without roots and leaves. On the other hand, the A of STEAM (Science, Technology, Engineering, Arts and Mathematics) education was somehow artificially pushed into the STEM education which continued being mostly STEM. She invented a new interpretation for STEAM:

S: Sciences (beyond physical and materialistic worldview and create new methodologies incl. arts)

T: Technologies (beyond the mechanistic mode to include ancient and indigenous methodologies)

E: Ecology (consider comprehensive inclusive ecologies from micro to macro)

A: Arts (expansive views of arts, not separated from science and technology)

M: Mindfulness (stop to think, all is interconnected)

As an example, to this approach Victoria mentioned her two residencies during the same time period, one in Japan in the doctoral program "Empowerment Informatics" and one with Charles Taylor an evolutionary biologist, who was trying to understand the state of the environment based on bird sounds. In Japan she learnt how to make bird origami and she learnt about the concept and computer models for self-organised-criticality from physicist Takashi Ikegami [38]. She then managed to combine all above disciplines in one art piece.

Victoria is also the North American editor of the Journal AI and Society, A Journal of Human Centered Systems.

Her message to all students, of all ages, is:

"Don't believe anybody who asks you to separate arts from sciences, because it's wrong and creates a lot of destruction and negativity in our world."

³² <http://artsci.ucla.edu/>

SciArt in the University of Nova Gorica by Peter Purg ³³

The University offers, under the leadership of Peter Purg, a variety of possibilities for Science and Art studies. The MAST³⁴, Module in Art, Science and Technology manual, was developed together with three other universities and NGOs and gives backgrounds on teaching and research in the (seeming) paradox between Social Values and the science-based technological progress. MAST wants to train the future innovation catalysts. The Innovation catalyst profile is to facilitate the actual innovation process that introduces art thinking as its key stage, before design thinking in the innovation cycle. Art thinking includes radical (self) criticism and questioning the entire frame of action, creative imagination, emotional and corporeal intelligence and a deep understanding of aesthetics.

Interdisciplinarity in Oslo Met University Presentation by Kristin Bergaust

OsloMet is located in the middle of Oslo city and has a lot of professional education. Kristin³⁵ is in the faculty of Technology, Art and Design and believes education at least in research should become more a combination of different disciplines. Kristin teaches in a master program Art and Society. Oslo Met is introducing a new Interdisciplinary PhD program with the title “Innovation in Sustainability” (PINS). The promoters of this course struggled to include Arts in it but in the end, Art does make part of the curriculum. First students to start in November 2023. Since the university is oriented towards professional studies, students are allowed to receive this PhD related to their own professional interests. The PhD has 3 mandatory courses in philosophy of science, method and innovation and interdisciplinarity and 5 elective courses addressing perspectives of sustainability concerning place, social, individual, aesthetics and education.

The unique approach of this PhD is the combination of design and aesthetics with computer sciences and social sciences.

Another interdisciplinary activity is the FELT³⁶ (Future of living technologies) project funded by the Norwegian artistic research program. FELT is a collaboration of 4 artists, 2 ICT researchers, 1 ICT PhD fellow, 2 humanities scholars and 1 Fulbright research fellow.

Learning from peers and other research environments has been important for FELT, therefore a number of fieldtrips, residences, seminars, workshops and visiting activities have been organized. As results they had artwork, PhD projects, postdocs, events, exhibitions and publications.

Examples include a master on “artistic representation of emotions from EEG signals”, or a PhD on “emotion technology”, or “transdisciplinary work-ethics”, which basically means how to avoid prejudice among disciplines such as treating the engineer as a technician and the artist as an illustrator. Within the FELT framework Maria Castellanos created the artwork “Other Intelligences” in which 24 plants world-wide are connected through the internet. The aim is to examine the behavior and communication ways of plants³⁷. Still another project, the “Metabolome” project, envisions possible and speculative convergences of machine technology and human bodies, sensing and empathy. A specific exhibition of it was on “developing care ethics for technology mediated care practices” focusing on future health care. Finally, Kristin presented her own artwork with the title

³³ <https://www.ung.si/en/research/research-centre-for-humanities/staff/peter-purg/>

³⁴ <https://mastmodule.eu/manual/>

³⁵ <https://www.oslomet.no/en/about/employee/kribe/>

³⁶ <https://www.oslomet.no/en/research/research-projects/felt>

³⁷ <https://mariacastellanos.net/>

“Ocean connections” which she produced in the framework with JRC’s SciArt project “Naturarchy”. The FELT project will be concluded in 2024.

Transdisciplinary Insights Honours Program³⁸ KU Leuven by Tam Nguyen

Tam is a PhD student who received two masters from KU Leuven, one in business administration and one in anthropology. The honours program is an extracurricular activity that students from all faculties can take starting from Bachelor to PhDs. The students are divided into teams and each team addresses a specific complex, multifaceted, even wicked problem, such as pandemics, climate change, education etc. Each team is accompanied by coaches, who are there mainly to advise and to support. It is the students who take the ultimate decision of where to take the project. The course is two semesters long based on the “Designing Feasible Futures Framework” that distinguishes four phases, framing, complexity, multi-level, futures. This framework is about how to go from what it is to how it should be.

Since students are from very diverse backgrounds their level of knowledge of the problem is very different. Framing module helps bring them all on the same level and from there develop their theory of change. During the complexity module they draw a complexity map, where all important parts are identified and connected with feedback loops. In the multi-level module stakeholders are identified and organisations or key figures are reached out to for feedback on the theory of change and the complexity map. The last part, futures, is about the production of the output, which can be very diverse and original.

The aim of the program is to see the problem holistically, reach out to stakeholders who may be affected negatively, be critical and present findings to a broad audience.

Generally students find the course worthy and thought provoking and stimulates transdisciplinary research, even at the PhD level.

The challenges of the course are:

- The very different backgrounds of the students, the different “languages” and disciplinary thought structures pose limits to collaboration
- The different levels of understanding
- Dominant voices create an unbalanced learning experience
- Measurement and evaluation of learning not easy
- Transdisciplinary programs do not have the structural support of other programs
- How to apply to another educational context

There is some research carried out at KU Leuven concerning the Transdisciplinary Insights (TDI) Course. Questions posed are:

- What competencies do students acquire through TDI.
- How to transfer the method to Vietnamese university context.
- How do students accept other knowledge and break out of their own identity labels.
- How to evaluate TDI courses.

³⁸ <https://rega.kuleuven.be/if/education-training/tdi/transdisciplinary-insights>

SciArt in Research

*JRC's Naturarchy Project*³⁹

JRC⁴⁰ is the European Commission's Directorate General concerned with the provision of independent, evidence-based knowledge and science, supporting EU policies to positively impact society. Naturarchy is the title of the 2022-2025 edition of JRC's SciArt Resonances Program. With Resonances JRC offers the possibility to its scientists to collaborate with artists in transdisciplinary way with the aim to:

- Communicate science, produced in JRC, in a way that it reaches the population
- Create debate among scientists and artists with the aim to explore new routes for policy making
- Push both scientists and artists to take new viewpoints for developing science and art that will benefit European society.

Naturarchy explores and tries to re-define the relation between humans and Nature. It moves along five themes, nature and law, decentralizing the human, techno green, changing the ground, circular Gaia.

Naturarchy kicked-off with the summer school of 20-24 June 2022, which was the first occasion to meet the 20 acclaimed artists selected through the Open Call (published Dec 2021, closed Feb 2022) in the JRC Ispra site, and allow them to interact with cutting-edge scientific research and public policy discussions. The artists submitted their proposals for artwork to be produced in collaboration with JRC scientists and European Commission policy officers. Based on those, JRC offered residences to 15 artists which took place between October 2022 and June 2023. In July 2023 the project entered the production phase and the exhibition is foreseen for summer 2024.

JRC's Feeling Science Project

This initiative was inspired by eight JRC women scientists as a way to speak up and occupy space, exploring the socio-cultural and political dimensions of women in science. The eight scientists felt they had to connect to the general public, to dispel mistrust to science by talking about their research, and to attract young women to scientific careers.

They talk about issues such as their love of science and their motivations to become scientists, the complexity of life, hierarchy and empathy. They examine the Joint Research Centre and the ways of scientific advice to policy making. They use the Greek myth of Minotaur to convey the complex notions of science for policy to the audience.

The eight women teamed up with one professional playwright and two theater directors to produce "Feeling Science" a theater experiment, which they performed themselves already on various occasions in Varese, Lugano and Monte Carlo.

³⁹ <https://science-art-society.ec.europa.eu/naturarchy-0>

⁴⁰ https://joint-research-centre.ec.europa.eu/index_en



2 JRC Scientists performing

COST project SHIFT⁴¹ by Fernanda Rollo

The project coordinator Fernanda Rollo thanked the CoP for the invitation, affirmed the commitment of SHIFT to collaboration and exchange and she invited the members of the CoP to join the project. Although membership is individual, the CoP can continue operating as a group and at the same time address the full SHIFT community. SHIFT is about engaging Social Sciences, Humanities and Arts in the challenges of Climate Change, with the aim to imagine a sustainable future, to up-scale desirable change and to allow for the emergence of new forms of learning and education. The project wants to give voice to marginalized groups and future generations. SHIFT sees itself as a transdisciplinary hub that brings together academia, policy, industry, practitioners, civil society and the emergent public. Engaging communities is core to SHIFT.

SHIFT has 260 participants from 37 countries and is still growing. The mission of SHIFT is to raise awareness about climate change and minimize its impact on our lives; it is about change and transformation and the role of arts and humanities.

SHIFT is organized in 4 WPs. The first WP is about new ways of knowledge acquisition and will organize a conference on the 18-19 September in Graz, Austria to explore concepts and ethics of Social Sciences, Humanities and Arts in relation to climate change. The CoP is invited to join the consortium.

The SHIFT Forum was launched in autumn 2023, and it serves as a seminar and discussion space. Again CoP members will be invited to participate. In April 2024 they will organize the SHIFT week completely dedicated to all activities and projects related to Climate Change. SHIFT organized a full session of ECCA 2023 (European Climate Change and Adaptation) Conference.

⁴¹ <https://shift-cost.eu/>

ARS Electronica⁴²

Ars Electronica Linz GmbH & Co KG is a company of the City of Linz and consists of the operational divisions Ars Electronica Festival-Prix-Exhibitions, Ars Electronica Center, Ars Electronica Futurelab, Ars Electronica Solutions and Corporate Services. The activities are always guided by the question of what new technologies mean for peoples' lives. Together with artists, scientists, developers, designers, entrepreneurs and activists, they shed light on current developments in the digital society and speculate about their manifestations in the future.

The Ars Electronica Futurelab is a laboratory and atelier for future systems. As the think-and-do tank of the Ars Electronica, it always places the human being at the center of the research, considering the social aspects of technological developments such as artificial intelligence, robotics, media architecture, interactive technologies, new aesthetic forms of expression or swarm intelligence and their effects on the future of society. Futurelab encourages each individual in the team to develop their own interpretation of art, technology and science, to exploratory transform it into new artistic spaces and to conquer unknown scientific terrain. The Ars Electronica Futurelab's current team members' research interests are:

Art thinking: What is the role of art in the 21st century? And how can we apply art for a better future society?

Artificial Collectives: How do we teach groups of machines autonomy, cooperation and expression?

Co-immersive spaces: How can we create Spaces to experience Virtual Realities collaboratively?

Creative Intelligence: Can machines create?

Future Narratives: How can stories of the future change the here and now?

Origami Robotics: How can the art and science of origami make robotics more natural in the future?

Symbiotic Creativity: The use of biology and chemistry to develop creative systems, methods, and technologies that interact, communicate, and co-create with living cells, organisms, and nature.

Tangible Link: How can we shape closer links between society and science?

SciArt in Lifelong learning

Book Presentation by Tatiana Chemi and Kristian Firing

Tatiana started by explaining that while we have talked about the art as a creational process for its own sake and the art as an instrument for the benefit of other sectors, there is a third way to think about arts. It is the collaborative way of doing art in a non-artistic context where artists contribute to the outcome of the work on an equal basis as the non-artists.

This work started as an Erasmus + project called "Artist Led Learning"⁴³. Artists were asked to be responsive but not accountable for the whole learning process in an academic learning setting. The project produced 4 booklets instead of one book. The 4 booklets explore a different topic of the artist educator alliance such as performance and performativity, affects and transformations, community and collective learning.

⁴² <https://ars.electronica.art/news/en/>

⁴³ <https://aauforlag.dk/produkt/andre/the-artist-educator-alliance>

Kristian presented an example of how performance art was used in a 9 week leadership course. As part of their leadership training the students were asked to perform their own piece for 60 min in a theater in the city center with an audience of 50 people. The students were accompanied by an actor and theater director throughout this journey.

It is such combined teaching in leadership programs that have the highest potential to bring change in organisations and impact societies.

The fifth book (not in the booklet collection but an independent anthology) is also a spin-off of the Erasmus + project. It is about Art and Health and explores the pedagogical aspects in order to focus on prevention. The book collects stories from different scientific traditions such as neuroscience, psychology, quantitative methods etc.

Kristian presented an example of how this was put in an educational context in the military. The example deals with death and how we learn about it in a respectful way. Death when in military action can happen any time but people usually refrain from talking about it. Such training involved talking to a person that had been injured in action and was to die in about 20 min. The aim was to push the students to think what they would say on such an occasion and to acknowledge the feelings they experienced. After that they must write a letter to be opened after their death in case they die in action. Throughout the process students realise that the whole exercise is not about death but about life and how they can change their ways of living to appreciate it more.

Sciart in business

Book Presentation by Chiara Paolino

The book *Innovating Business with Arts* [39] is the translation in English of an earlier edition in Italian. It is about the arts program of the Fondazione Casoli⁴⁴, which is tied to the company Elica producing kitchen aspirators. The company has a very attentive approach to art, seeing art not as an instrument for company success but more valuing and enabling the artist throughout their career. Chiara describes in her book the process of the artists as they enter the company and start working together with the employees and learn from them. This knowledge is then transferred outside the company to the various social and professional groups with which the artist engages. Hence, one part of the book deals with how art can foster knowledge exchange and aesthetic learning. In the last chapter, which was written after the pandemic, she deals with the transformations of the artists themselves having worked in a commercial setting during the pandemic and the connections they've built with the company's employees.

⁴⁴ <https://www.fondazioneecasoli.org/>



3 Streetart CEI P.Porto



4 Microfluid Oracle Chip & Autopoiesis Answering Machine (MOC&AAM) by Agnes Meyer-Brandis (Ars Electronica Festival)

Epistemologies of SciArt- a discussion

Knowledge and Education

Our education system is based on epistemological principles such as causality, reductionism and observability, which, now we know, are not anymore either suitable or sufficient. Instead, we have to introduce terms like complexity, interdependencies and interconnections and uncertainty. Concepts that we are not used to, and we have difficulties dealing with. The Arts can help bridge the gap. SciArt can bring new methodologies and new creativity in all fields and help us convey these new concepts in all levels of education and professional life.

The contamination of knowledge among disciplines will create new hybrid figures, so much needed to address the wicked problems of today. These figures should be based on holistic thinking, be critical of easy solutions, empathetic and open to new viewpoints. Currently knowledge is fragmented and compartmentalised and scientists are not considered as such if they move among or across disciplines. The disciplinary approach doesn't offer enough contamination among disciplines to help respond to the needs of today. There is an urgency to go towards a transdisciplinary approach not only concerning our education but also in our careers and professional and personal development.

This does not mean that disciplinary education should be abandoned but rather complemented with transdisciplinary education.

For that we need a collection of Pedagogies for transdisciplinary educational programs, lifelong learning and even simply new ways of developing and transferring knowledge. Currently, there are no pre-established methods or training. Everything is very much experience-based and -driven. New creative educational designs should come forward based on SciArt.

SciArt should not be used to achieve more growth in society but to propose new societal systems. SciArt is also not a cure, it is more a way of creating new relationships, exploring and transforming old ones and navigating through chaos. The first step to bring science and art closer to each other is by fostering the dialogue and the discussion culture. This is how people listen to each other and take each other seriously. Currently, there is mistrust and skepticism that we must overcome to learn from each other. Education is crucial during this process.

SciArt and transdisciplinarity has the potential to create surprise and stimulate curiosity and lead people towards a new era similar to how universities opened up the minds of the people during the renaissance.

Universities

Universities are key structures for transdisciplinarity. They hold the potential of new ways of learning and disseminate most effectively the outcomes of scientific research. However, universities are crystalised structures of departments with their own hierarchies and budgets and pose resistance to change. Some universities claim to offer problem-based thinking and education but most of the time they approach the solution with the same thinking and methods that created the problem in the first place.

Some of the CoP professors noticed that students of today have adopted the thumbs up culture at a degree that makes them too scared to make mistakes. They seem not to have the courage to experiment and fail from fear of disapproval. Failure though is an important trigger of learning. After

the pandemic this tendency accentuated to a degree that critical thinking needs to be inserted in the curricula.

One of the most important global trends for the next decade is transdisciplinarity. But it is not really about transdisciplinarity versus specialization, neither it is about in the university or out of it. It is more about acknowledging the complexity and the variety of things that are already happening. It is about new knowledge. The knowledge we seek shouldn't be about institutions or buildings or equipment, but it should be about people and their lives on this planet.

For this we may think of a new structure, such as the multiversity, that connects teachers and students across universities. People who want to experiment with the acquisition of new knowledge without administrative burdens and disciplinary rules.

We need to create a real international transdisciplinary PhD course. Current PhDs are branded transdisciplinary but they are mostly carried out within some existing discipline. To create real transdisciplinary programs, we need to re-think the epistemological and methodological assumptions that underpin knowledge and learning.

Moreover, we need satellite structures, such as this Community of Practice that bring together different people with their various methodologies and value systems but it can also start devising courses that we can present to universities to be taken on their schedules.



5 Visionary music (core research question is how to develop and design visual musical instruments) by Gerald Peter Ars Electronica Festival

Art Exhibitions

During the duration of the project the CoP members were involved in important exhibitions.

ASTER Exhibition Seville⁴⁵

Promoting Art-Science-Technology-Engineering Research by using collaborative methodologies and tools. ASTER is the latest of these projects funded by the EU's regional funds. The aim of the project is to build bridges that will allow communication and collaboration between different ways of understanding the world and conceiving the construction of knowledge.

The project kicked off with a hackathon between scientists and artists. The scientists were asked to plant a "scientific seed" of a current topic, name it, give keywords and an abstract, describe the scientific method, use metaphors and metaphysics, assign colour aromas and taste to the seeds.

The seeds served as an inspiration for the interdisciplinary teams created around and germinated into "SciArt flowers" i.e. art pieces. The 16 art pieces were exhibited in "Fundación del Colegio Oficial de Aparejadores y Arquitectos Técnicos (COAAT)". The production of the 16 Art pieces costed 10000 Euro.

The art pieces are:

Light Photosynthesis/Dark Photosynthesis	SciArt Video Installation
Rigor Plastic, Metamorphosis in a circular economy	SciArt Installation
Camarina the pearls of the dunes	SciArt audiovisual Installation
The inaudible Howl, The skin of the soil	SciArt Installation
The complexity of the simple	SciArt Installation
Limit Cycle	SciArt Installation
The mismatch, Human and Machine Behaviour	SciArt Installation
Biases and Machine Translation	SciArt Video
Nothing	SciArt Installation
Formalisation of Knowledge	SciArt Video
Twenty times true	SciArt Installation
emergANT	SciArt Installation
Too common and meaningless	SciArt Microtheater
Ai manifesto and incidental music	SciArt Performance
I am the real you	SciArt Performance

⁴⁵ <https://aster.us.es/en/proyect/>

Three of the above art pieces have been already allocated to be exhibited in the next Ars Electronica show of September 2023.

The exhibition won the first prize for the best Andalusian exhibition and the second prize for the most popular exhibition. The prizes were awarded by AMMA (Association of Museologists and Museographers of Andalusia).



“Plastic Rigor. Metamorphosis in a circular economy environment”

Authors:

Eduardo Julio Lavrador Jiménez
María Díaz Osta
Yolanda Martín Benítez

Technical Specifications:

-SciArt installation (transparent urn, soil and plant substrate, porexpan figure, Zhophoba Morio worms, surveillance camera connected to Raspberry Pi)
- Dimensions: 150 x 50 x 150 cm.

The images alternate in two moments, corresponding to the light phase and the dark phase of the photosynthesis process of the plants; that is, day and night. When the visitor approaches the work he hears a melodic sound. The sound is one more sign of the subtlety of the natural processes of plants.



“Roots, relations between the computational and the human”

Authors:

Mariano Luque Romero
Miguel Mendoza Malpartida
Cecilia Pineda Calvillo
Esther Rodríguez Pluma
José María Delgado Sánchez
Pedro Escobar Rubio

Technical Specifications:

-SciArt installation (hemstitch, screen printing and interactive digital projection -projector, motion detector and RaspBerry Pi-)
- Dimensions: 200 x 200 x 300 cm.

When the visitor approaches the work, it is activated. From a ceiling-anchored projector, an artificial life pattern is generated on the floor and the sculptural piece that branches out like a root..

Cultural Collision Exhibition Vienna⁴⁶

Cultural Collision held a series of events during the academic year 2022/2023.

Initial exhibition at the TU Wien, 31.01. - 02.02.2023

The kick-off was the inspirational exhibition "Climate and City in Transition". The participatory exhibition invited you to visit five stations curated and realised by students and teachers of the Faculty of Architecture and Planning. In addition, works by the artists Daniela Brill Estrada, Monica C. LoCascio and Rolf Laven were shown.

The aim was to convey scientific content in a playful, experimental confrontation, which is subsequently further developed artistically by the participating classes in their individual lessons.

Art and cultural education workshops in the museums, March/April 2023

The semester was accompanied by experts, e.g. from the Vienna Museum of Science and Technology on science education. In addition, there were workshops for school classes at the Museum of Modern Art, which focused on the topic of art education.

Final exhibition of the students' works at the Mumok – Museum moderner Kunst Stiftung Ludwig Wien, 23.06. - 25.06.2023

The finale of the pilot round was the exhibition of the students' works at the end of the school year at the Mumok – Museum moderner Kunst Stiftung Ludwig Wien.



7 Kids learn by playing in TU Wien

⁴⁶ <https://www.tuwien.at/en/cultural-collisions>



8 Kids co-create art on the subject Climate and City in Transition

ARS Electronica Festival Linz⁴⁷

The annual ARS electronica festival with the title “Who owns the truth” took place from 6th -10th September in Linz. This was a huge event in many different locations of Wien but mostly Postcity. It attracted around 88000 visitors and included 650 exhibits and 575 related events.

⁴⁷ <https://ars.electronica.art/who-owns-the-truth/de/>



9 The logo of 2023 ARS Electronica Festival in Linz

Conclusions

Science must be liberated from its strictly disciplinary approach to tackle sustainability and other wicked problems of our times. Disciplines are considered as responsible for the current climate and biodiversity degradation and there is a consensus that scientific disciplines alone are not capable of taking humanity on the path out of the climate crisis and in a path of giving nature its juridical rights.

The mind must be liberated from thoughts of human supremacy and reductionism. It has to be trained in empathy and symbiosis and to cope with complexity, since this is the only viable way for maintaining climate conditions on the planet that favor humans to thrive in the long-term.

A new education at all levels has to be designed and delivered to satisfy the previous two conditions. The notion that we must enter a discipline in order to have a future profession needs to be dropped. Universities already offer new problem-oriented approaches to education that need to be consolidated and enriched. There is an appreciation that knowledge may lay with groups beyond institutions such as indigenous and traditional knowledge for preservation of nature.

Sustainability considerations with the accompanied European funds for research has sparked off a proliferation of transdisciplinary courses and degrees in the universities of Europe. Such inter- and transdisciplinary education is considered better suitable to tackle the big societal problems and to trigger the transformation needed to avoid a climate collapse at planetary level within this century.

While funds for transformation become increasingly available, universities find it hard to change due to tradition, stakes, territorial divisions, inertia, fear etc. It has been noticed that newer universities are more flexible and willing to try new methods of learning and knowledge acquisition.

As the future is approaching, the need for SciArt in education becomes apparent. The economy will go into a post-growth working modus, pushed by a generation that cherishes work flexibility, well-being, impact, care and creativity more than profit and by the new technologies of AI and quantum which are naturally transdisciplinary and force us to rethink reality.

Art seems to be taking an important role in transdisciplinarity. After centuries of exclusion, the arts are back ready to join the sciences in an attempt to observe the whole and not only the scientifically relevant and factual but also the emotional, the ethical and the aesthetic.

Schools and universities have very little experience of including art in science learning and the offered courses are mostly experimental. There is little if any guidance for teachers and researchers. There is also little feedback from industry and services on hybrid professional profiles needed and there is hardly any evaluation capability.

Scholars and teachers struggle to satisfy the needs of the new generation for abolishing fossil fuels, protection of biodiversity, a plastic free environment, ethical industrial practices, gender and racial diversity, response to crisis, along with increased digitization, AI pervasiveness, social media and mental issues etc. There is too little offer of such teaching in the universities while at the same time the European youth is fully emerged in this reality.

While universities are overwhelmed by such requests they also must keep up and running the ever-growing number of disciplines required for the extreme specialization needed by the industry of today.

Publishing houses have also felt the need for change. They seek to include societal impact in their future evaluation methods for research papers along with interdisciplinarity, diversity and inclusion of the research teams⁴⁸.

Future needs

More transdisciplinary courses, particularly SciArt courses, within and across universities are needed. Transdisciplinarity and SciArt could become the foundation for the multiversity (as opposed to university), in which disciplines and practices across universities could be connected and combined without the usual administrative burdens of academic institutions.

Courses should be offered in all possible combinations and with all possible knowledge groups in society and not only the usual stakeholder culture.

Because such variety is endless, universities should not strive to cover all but to offer diversity. Students should be allowed to combine universities in their attempt to approach problems from various angles.

New evaluation methods of such courses need to be developed by taking into consideration both the impact on personal growth and the impact on the society and economy of Europe.

Way Forward of the Community of Practice

The CoP has identified the following next steps:

- Prepare a complexity map to make sure we have collected all relevant issues.
- Involve students in the CoP meetings to collect their views.
- Continue collecting good practices.
- Involve the industry and the services in the discussions in order to collect professional needs for hybrid figures.
- Develop this report into a book

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⁴⁸ <https://www.elsevier.com/academic-and-government/research-evaluation-and-impact#1-future-of-evaluation>

REFERENCES

- [1]Sun, J.; Yang, K. The Wicked Problem of Climate Change: A New Approach Based on Social Mess and Fragmentation. *Sustainability* 2016, 8, 1312. <https://doi.org/10.3390/su8121312>
- [2]Sharman, Martin, and Musa C. Mlambo. "Wicked: The problem of biodiversity loss." *GAIA-Ecological Perspectives for Science and Society* 21.4 (2012): 274-277.
- [3]SPICKER, P. Poverty as a wicked problem. CROP poverty brief, no. 35 2016. Bergen, Norway: CROP Secretariat [online]. Available from: <http://www.crop.org/viewfile.aspx?id=1062>
- [4]Lawrence, Mark G., et al. "Characteristics, potentials, and challenges of transdisciplinary research." *One Earth* 5.1 (2022): 44-61.
- [5] Peña-López, Ismael. "Addressing societal challenges using transdisciplinary research." (2020) OECD Publishing
- [6]Applying Interdisciplinarity: The encyclopedia of World Problems and Human Potential, UAI <http://encyclopedia.uia.org/en/strategy/206198>
- [7]Mieke van der Bijl-Brouwer, Giedre Kligyte, Tyler Key, A Co-evolutionary, Transdisciplinary Approach to Innovation in Complex Contexts: Improving University Well-Being, a Case Study, She Ji: The Journal of Design, Economics, and Innovation, Volume 7, Issue 4, 2021, Pages 565-588, ISSN 2405-8726, <https://doi.org/10.1016/j.sheji.2021.10.004>.
(<https://www.sciencedirect.com/science/article/pii/S2405872621001118>)
- [8] Miwa A. Takeuchi, Pratim Sengupta, Marie-Claire Shanahan, Jennifer D. Adams & Maryam Hachem (2020) Transdisciplinarity in STEM education: a critical review, *Studies in Science Education*, 56:2, 213-253, DOI: 10.1080/03057267.2020.1755802
- [9]Cockburn J., Knowledge integration in transdisciplinary sustainability science: Tools from applied critical realism, *Sustainable development special issue* 30(3), December 2021, DOI: 10.1002/sd.2279
- [10] Plummer, R., Blythe, J., Gurney, G.G. et al. Transdisciplinary partnerships for sustainability: an evaluation guide. *Sustain Sci* 17, 955–967 (2022). <https://doi.org/10.1007/s11625-021-01074-y>
- [11] de Geus, T., Avelino, F., Strumińska-Kutra, M. et al. Making sense of power through transdisciplinary sustainability research: insights from a Transformative Power Lab. *Sustain Sci* 18, 1311–1327 (2023). <https://doi.org/10.1007/s11625-023-01294-4>
- [12]Dominici P. Beyond Black Swans. Managing Complexity: A Contradiction in Terms?, 2021, World Organisation of Systems and Cybernetic Congress, pp119-131
https://link.springer.com/chapter/10.1007/978-3-031-08195-8_12
- [13]Dominici, P. "From Emergency to Emergence. Learning to inhabit complexity and to expect the unexpected", 2023/1, *Salute e Società* <https://academia.edu/resource/work/99942554> , pp. 135-151
- [14]Dominici, P. "Beyond the Darkness of our Age. For a Non-Mechanistic View of Complex Organization as Living Organisms" 2022, RTSA http://rtsa.eu/RTSA_2_2022_Dominici.pdf?fs=e&s=cl
- [15]Dominici, P. "Educating for the Future in the Age of Obsolescence", 2021, CADMUS, <https://academia.edu/resource/work/44784439>

- [16]Dominici, P. “The Digital Mockingbird: Anthropological Transformation and the “New Nature”, Feb. 2022, World Futures. The Journal of New Paradigm, Routledge, Taylor & Francis, <https://doi.org/10.1080/02604027.2022.2028539>
- [17]Dominici, P. “The weak link of democracy and the challenges of educating toward global citizenship”, 2002, Prospects <https://doi.org/10.1007/s11125-022-09607-8>
- [18] Bell John “Against Measurement”, 1990 Phys. World 3 (8) 33
- [19] Barad Karen Meeting the Universe Halfway, 2007, Duke university Press
- [20]Chen Sophia, The future is quantum: universities look to train engineers for an emerging industry, 2023, Nature 623, 653-655 (2023) doi: <https://doi.org/10.1038/d41586-023-03511-7>
- [21] Cao, L. Trans-AI/DS: transformative, transdisciplinary and translational artificial intelligence and data science. Int J Data Sci Anal 15, 119–132 (2023). <https://doi.org/10.1007/s41060-023-00383-y>
- [22] Kusters R., et. al. Interdisciplinary Research in Artificial Intelligence: Challenges and Opportunities, 2020, Frontiers in Big Data, Vol 3 DOI=10.3389/fdata.2020.577974
- [23] Tuomi, I., Cachia, R. and Villar Onrubia, D., On the Futures of Technology in Education: Emerging Trends and Policy Implications, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/079734, JRC134308
- [24] Daniel Durrant, Christian Lamker & Yvonne Rydin (2023) The Potential of Post-Growth Planning: Re-Tooling the Planning Profession for Moving beyond Growth, Planning Theory & Practice, 24:2, 287-295, DOI: 10.1080/14649357.2023.2198876
- [25]Limits to Growth 1972 Club of Rome
- [26] Pansera, M., & Fressoli, M. (2021). Innovation without growth: Frameworks for understanding technological change in a post-growth era. Organization, 28(3), 380-404. <https://doi.org/10.1177/1350508420973631>
- [27] Root-Bernstein, R., Allen, L., Beach, L., Bhadula, R., Fast, J., Hosey, C., ... & Weinlander, S. (2008). Arts foster scientific success: avocations of nobel, national academy, royal society, and sigma xi members. Journal of Psychology of Science and Technology, 1(2), 51-63.
- [28] Silveira, J. Artscience, STEAM, SciArt, SEAD and Much More: Multiple Names for a Complex and Transdisciplinary Research Field. Preprints 2021, 2021080046. <https://doi.org/10.20944/preprints202108.0046.v1>
- [29]Edwards D., Creativity in the post-google generation, 2008, First Harvart University Press
- [30] Heras, M., Galafassi, D., Oteros-Rozas, E. et al. Realising potentials for arts-based sustainability science. Sustain Sci 16, 1875–1889 (2021). <https://doi.org/10.1007/s11625-021-01002-0>
- [31] Braund, M., Reiss, M.J. The ‘Great Divide’: How the Arts Contribute to Science and Science Education. Can. J. Sci. Math. Techn. Educ. 19, 219–236 (2019). <https://doi.org/10.1007/s42330-019-00057-7>
- [32] Hoch Michael, Cultural Collisions, a cross disciplinary science education format, 2020, Proceedings of Science, 40th Int. Conference on high energy physics (ICHEP) 2020 Prague Czech republic

- [33] Van den Akker R, Noordegraaf-Eelens L, van Eekelen BF, Teeuwen R. Delta Studies: 7 Propositions for Arts/Sciences Education. European Journal of STEM Education. 2021;6(1), 18. <https://doi.org/10.20897/ejsteme/11394>
- [34] Latour, B. (2010). An Attempt at a "Compositionist Manifesto". *New Literary History*, 41, 471-490
- [35] Haraway, D. (2016). *Staying with the Trouble: Making Kin in the Chthulucene*. Durham: Duke University Press. <https://doi.org/10.2307/j.ctv11cw25q>
- [36] Bhabha, Homi K. (2004). *The Location of Culture*. Abingdon: Routledge. p. 55.
- [37] Sarmiento C., Pascoal Cerqueira S. *Cultural Tourism and Heritage in Northern Portugal*, 2020, Cambridge Scholars Publishing
- [38] Yada Y., Mita T., Sanada A., Yano R., Kanzaki R., Bakkum D., Hierlemann A., Takahashi H. 2016, Development of neural population activity toward self-organized criticality. *Neuroscience*. 343. 10.1016/j.neuroscience.2016.11.031
- [39] Care D. Paolino C., Smarrelli M. 2020, *Innovating Business by Art*, Bocconi University Press

Annex

Summary of the discussion on SciArt in education

JRC' SciArt Summer school June 20-24

Which are the challenges our education system doesn't manage to meet?

The environmental and societal challenges are too great to be dealt with in the usual ways. Climate change is global and requires innovative ideas to confront it and to promote sustainability. Both technical and social innovation are required now more than any time in the past, and it ought to be of a radically new kind, not only by ways of how it is organized and promoted, but also in the way its methodological framework is assembled and validated. While in the past innovation was left to chance and to charismatic persons today we know that innovation can be trained on several different levels, and in a range of different (inter)disciplinary combinations, if only school and university curricula will not only accept it as coming from the outside (such as from NGO, business or policy sectors), but also breed a manifold culture of innovation within the educational system, deeply integrated with its curricula and institutional or community practices. On the other hand the school system's classrooms have remained the same since the beginning of the industrial revolution and schools have lost their appeal to the young generations, regardless of many e-learning developments on both (top-down instigated) software and hardware levels, and even in (bottom-up emerging) didactics. With the omnipresent smartphone teachers are not anymore the exclusive source of knowledge. Pizzigoni's scuola rinnovata in Milan, operating for almost hundred years, however uses the whole environment as a classroom and nature as the teacher.

How should the education system change?

Higher education has to become more trans-disciplinary and promote experience learning and collaborative work, while the obviously prioritized STEM and natural-sciences promoting trends need to truly and deeply embrace the Arts and grow up to the promise of a STEAM-based inclusive and holistic, but at the same time daring if not critically disturbing innovation. A broader and more consistent inclusion of Humanities and Social Sciences into teaching innovation is then a next, perhaps even more challenging step that would truly tap into the entire range of disciplines to be considered for the right topical or methodological mix when tackling mind-boggling paradoxes and challenges of the near human future. The classroom has to be extended and use more of the natural environment. Curiosity and creative thinking has to be stimulated continuously. The classroom has to become the proponent not only of a cultural change but of a culture in changing. Since teachers are not anymore the only source of knowledge they have to become learning assistants. Teachers are motivated and understand the need for them to be aware and trained in new methods.

How can SciArt help?

Both science and art create cultures and follow a similar process of work thought questioning, critical thinking, observation, trial and experimentation, evaluation and repetition, as well as more

radical methods such as intuition, imagination, inspiration, abstract sensing, embodiment, over-sensitivity, serendipity, story telling, over-identification, radicalism, over-consistency, non-work, dis-novation, etc. Learning from errors as much as success and embracing paradoxes of the human condition, human existence and connections among fellow humans, and to nature, is a very important part of this chain, which in the schools has been unfortunately side-lined. SciArt in primary and even secondary schools seems to work well on a very basic level, opening up the minds and bodies for cross-disciplinary combinations of thinking and doing (together). However higher education still seems to be suffering from in-silo mindsets and specialisation. While a certain kind and amount of specialisation is needed, trans and interdisciplinary approaches have also to be strategically promoted, organisationally supported, funded and awarded. But this requires a strong political will, a well targeted policy-level and decision-making influence, and an appropriate new system of evaluation and accreditation throughout all educational layers. Education has to bring more sectors in contact with each other in spite of staying within the matrix of disciplines. It should become an exstition as opposed to an institution in which artists and activists can walk in and out without being treated as the mistakes of the system.

Are teachers and professors ready for the change?

The institutions have to support substantial change, but if this is not possible we have to support teachers with tools and methods, to move things from inside, they need both hi-quality training and incentives to actually start using them, and to evolve their didactics accordingly. The teachers are ready but the school is not. University professors still too often also find transdisciplinarity challenging, or even contrary to their institutional or individual career ambitions. The school curricula do not leave time and do not set the scene (both in terms of curricula as well as equipment and spaces, incl. school external-locations) for experimentation with new models, and participation of (school-external) stakeholders. Massive and well concentrated, directed support should be given to teachers to go out of their comfort zone and acquire new skills and credentials to guide pupils and students through change. The upcoming JRC CoP (Community of Practice) on SciArt in education is one way as is the https://joint-research-centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en and the council recommendation on learning for environmental sustainability, as well as social innovation, through as well as by art and culture.

Question from the audience

Education system is so crystalised that other modes of learning outside of the current structures have to be envisaged.

Answers

1. One way is the SciArt programs offered today. These experiments are set up in an ad-hoc manner locally and can be run if they obtain funding either through the local policymakers or through the Museums. Museums can becomes future learning hubs.
2. In recent years there has been an increase of school drop outs. Although the structure may be crystalised an increasing number feel they prefer alternative ways of learning
3. We should behave like a good healthy virus attacking crystalised forms....

Question from the audience

EU's green competence activities seem in silo. How can we be directly engaged in that.

Answers

1. Become a member of the CoP Tool "education for climate coalition" and feel free to create.
2. Don't always think of the heads of a society but allow for the "peripheries" to make their voices heard
3. The commission has also developed a framework on digital competences

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