Integrating Artistic and Scientific Practices into Organisational Endeavours

LONG READ

Author: Bianka Hofmann

Artists and creatives not only touch, entertain, and amaze with their works, but they also explore the impact of scientific findings and new technologies on society and consider alternative developments. This close connection involves negotiating values and dealing with incomplete knowledge. How do we want to live together? What decisions must we make despite only partially understanding their effects? These central questions are what make joint art and science projects so valuable. How can we create spaces where these discussions on values can occur early on, allowing citizens to influence technological developments? The challenge lies in comprehending new methods and their effects, ideally enabling us to contribute to their shaping. It is not just about speculating on future technological applications; it is about determining who will be involved in developing these new procedures. New scientific findings and their resulting technological developments can be assessed differently depending on their impact on an organisation, society, or an individual. What indeed constitutes relevant, innovative developments in science and technology? Furthermore, what challenges and ethical questions do individual scientists and developers face?

In this overview article, I provide examples of multi- and trans-disciplinary transformative spaces and the requirements for creating them to address the issues raised. I provide insights into artistic projects and the creative practices of scientists themselves and into the joint projects of artists and scientists, integrated into various working fields within a software-oriented research organisation in applied science. Our goal has been to foster genuinely innovative engagement and communication with new stakeholders, promote self-driven human resource development, and find new ways to impact society. We empower both employees and partners to expand their areas of responsibility and take ownership of their actions. Artistic works can facilitate access to highly complex technology and science, building bridges for a broader audience and facilitating exchange among affected stakeholders. Artistic and creative practices are increasingly entering the realm of research and development (R&D) to tackle complex issues and address social, environmental, and economic challenges in new ways. The digital age has led to a trend towards the scientification of art. Scientists, artists, and other creators increasingly use the same tools, methods, and software. Scientists use creative or even artistic practices, but these are not necessarily considered in the organizational self-conception or working procedures. Art already plays a role in exploring new technologies, applications, and the resulting possible societal challenges. Additionally, creative and artistic practices allow for critical reflection, igniting inner motivations, discovering talent, and fostering participation in collective action and a sense of belonging. Art can help employees and citizens take an interest in new developments, encourage individual responsibility, and strengthen their ability to adapt. Through aestheticisation and co-production, Sci-Art projects allow positive connections to STEM sciences, facilitating multidirectional dialogue, knowledge transfer, and communication.

Creating the Preconditions and Contexts for Temporary Transformative Spaces; Example Fraunhofer MEVIS

The Fraunhofer Institute for Digital Medicine MEVIS, comprising approximately 150 staff members, is dedicated to advancing digital medicine. The scientists at Fraunhofer MEVIS address the growing complexity of healthcare by designing and developing software solutions that enhance data integration and interpretation. As the comprehension of pathologies expands, we see new diagnostic and therapeutic tools emerge. The resulting multidimensional and multidisciplinary processes for diagnosis, therapy decisions, and monitoring need to be handled with efficiency as part of a cost-driven healthcare system.

Medical science is systematised knowledge that sheds light on how conclusions are reached and identifies potential sources of error. But it is crucial for medical science to determine whether this knowledge is reliable. Consistent management of sources of error in humans and technology (including AI) will be indispensable in allowing systems to increase safety, productivity, and quality in medicine. To achieve this, certain prerequisites must be in place, including a positive error culture,

robust and inclusive governance structures in participatory working environments, multi- and transdisciplinary cooperation, and international networks.

MEVIS offers a work environment that values lateral leadership, shared responsibility, and participation. The aim is to cultivate high engagement and individual entrepreneurial behaviour, fostering success within the organisation. The researchers come from a wide range of STEM disciplines and have the freedom to work autonomously within a self-organised dynamic network. Project teams are formed to include members with diverse technological and clinical backgrounds, allowing to leverage each individual's collective expertise and experience. The non-hierarchical and dynamic collaboration promotes individual multidisciplinary training and cooperation, benefiting employees and the organisation. MEVIS' internal communication is governed by transparency to empower employees and harness everyone's potential for growth.

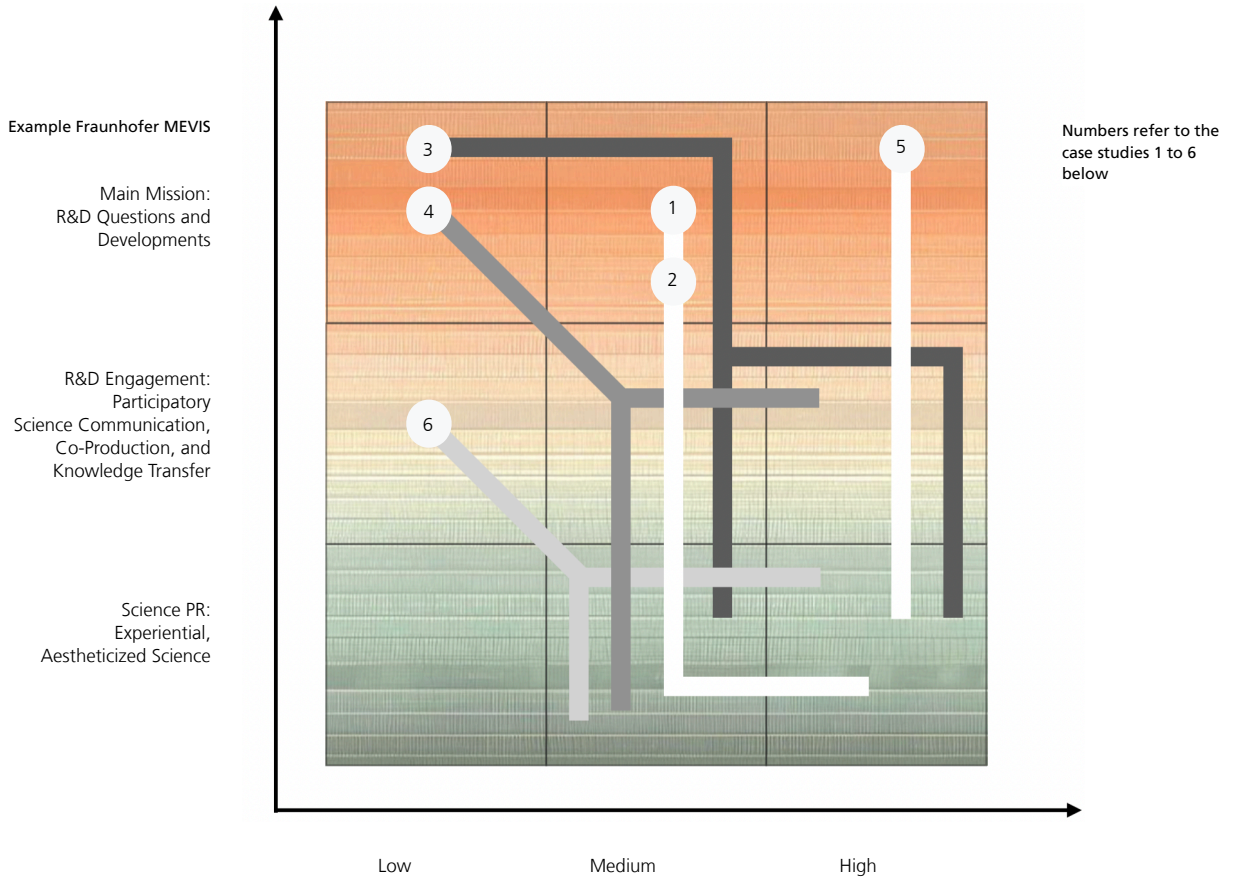
All team members are welcomed in any meeting that interests them, and access to all documents and business information is granted to everyone. Restrictions only apply due to legal constraints or confidential agreements with partners and customers. Information sharing is expected and facilitated through exchange forums like the wiki-based intranet. In addition, self-motivated initiatives by staff members beyond their current work assignments are encouraged. These fundamental principles are reflected in participatory Sci-Art projects. These projects involve contextualised responsible research and creating science-inspired or -informed artwork, emphasising learning and science engagement. They also provide researchers with the means to address their work's broader impacts and social dimensions. Within these projects, artists and scientists assume various roles, ranging from consultants to co-creators, research partners, and even STEAM (Science, Technology, Engineering, Arts, Mathematics) teachers for school students.

Complex and socially relevant issues, such as accessible and affordable healthcare, environmental and climate protection, and lifelong learning, require reconsidering priorities in developing product-ready solutions and services. Success can no longer be solely defined in terms of profit and efficiency. The complex crises we face demand diversity, social dialogue, skills development opportunities, and community access to knowledge. How can new spaces for transformation that address these tasks into the structures, fields of action, and work processes of an organisation gradually be integrated?

Integrated Artistic and Scientific Practices: Strategic Alignment for Meaningful Outcomes

The key lies in aligning Sci-Art projects to the specific goals of the institute's broader mission. This alignment ensures that the projects are directly anchored to the staff's expertise and activities in a participatory manner while also integrating new stakeholders. By doing so, joint artists' and scientists' undertakings can generate meaningful outcomes. The institute's team of scientists and creative partners collaborate to expand the collective sphere of solutions through mutual learning and creation. This collaborative effort extends beyond the organisation and fosters integration within a specific sector, as illustrated in the accompanying graphic below. These principles can also be adapted and applied to other industries and subject areas.

In the following diagram, the x-axis represents the degree of alignment with the methods, principles, tools, and procedures used to achieve the main missions of an organisation. At the same time, the y-axis indicates the artist's or creator's involvement with the organisation's specific objectives. For instance, in addition to the company's main mission, one could focus on Human resources, diversity, or sustainability aims and missions. Fraunhofer MEVIS has focused on 1) experiential science Public Relation, 2) participatory science communication, co-production, and knowledge transfer (summarised as strategic R&D engagement), and 3) the R&D questions and developments driven by the institute's primary mission. At Fraunhofer MEVIS, R&D engagement and cooperation with artists and filmmakers are considered unique opportunities to reach new and diverse audiences; share the impact of new technological developments; facilitate emotional, positive encounters with science; create contemporary science engagement formats; and allow staff to explore interests beyond their daily work.

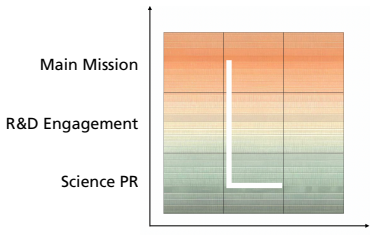


Initially, there was no established programme for Sci-Art projects at the research institution Fraunhofer MEVIS. Instead, discussions were held with scientists who were either eager to push boundaries with their research tools or were creative drivers in public engagement. The residency programme 'STEAM Imaging' was created, aligning with the scientists' expertise and interests. It facilitated the development of Sci-Art projects and established research collaborations with artists. We established a collaborative learning room and have deviated from established procedures and workflows. The role of the initiator, mediator, and project developer is to pave the way for establishing connections and building bridges that facilitate the realisation of aspired outcomes. Artistic practices have the potential to reveal innate talents and interests. Getting creators on board, fostering endeavours such as participatory science communication and multidirectional models of knowledge transfer within an organisation, and developing joint projects with additional stakeholders can refine and enhance a company's mission. It enables us to view staff and partners as citizens while considering an institution or company as a powerful driver for addressing socially relevant topics.

Addressing the Institute's Research & Developments: Bringing Relevant Topics to Unusual Forums, Making them Accessible to a Broader Public

Main Mission Integration: Medium
R&D Engagement Integration: Medium
Science PR Integration: Medium to High

Realized Formats: Interactive exhibits, immersive audio-visual 2D, stereoscopic 3D, and hemispheric installations
Specific Aims: Addressing actual R&D technologies, procedures and topics in digital medicine. Reaching non-tech-affine audiences, allowing them to build emotional positive relations to STEM & tech and topics around severe diseases. Approaching digital medicine through artistic lenses.



See case studies 1&2

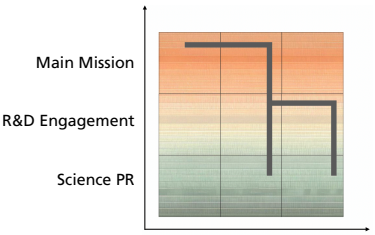
Projects within this category utilise and/or provide access to outcomes and technologies that align with the research objectives of the institute's primary mission. Based on real medical images and data, scientists created with 'MeVisLab' (a software platform they usually use to develop assistant tools for clinicians) immersive audio-visual 2D, stereoscopic 3D short films and large-scale hemispheric installations. Looking at medical data from an artistic perspective enabled them to bring abstract concepts and severe health topics into a tangible realm to the public and to new places. Additionally, aesthetic elements and artistic approaches can influence researchers' reflection on their work topics.

Artistic perspectives and innovative approaches to research necessitate the capacity to play literally with technologies and leverage expertise and domain knowledge in an inclusive and collaborative environment. The roles of leader and creative driver, giver and learner, are fluid. At the same time, it is crucial to be aware of the context in which the material is produced, investigating the occasion and the intended users or audience. See case studies 1 and 2.

Approaching R&D Topics Through Artistic Lenses and Practices: A Culture and Mindset of Collective Sense Making

Main Mission Integration: Low to Medium
R&D Engagement Integration: Medium to High
Science PR Integration: Medium to High

Realized Formats: Creators Residencies; outcomes include: audio-visual installations, AR sculpture, sound device development, sound installations, live performances
Specific Aims: Creating engaging artworks. Approaching digital medicine with artistic practices, engaging the next generation in R&D topics and tools, discussing actual challenges in digital medicine, and experiencing STEM and tech with awe and fun.



See case study 3

The goals of the creators' residencies range from engaging staff in arts-based training to sustained dialogue with the broader public to develop and co-create collaborative projects with scientists, the next generation, and the community to establish new multi-stakeholder R&D spheres. Artists can drive innovation in science engagement. Special requirements and prior knowledge apply to artists who enter a joint sphere within the research department. In both cases, it is essential to refrain from instrumentalising artists. To ensure that the artists' strategies can thrive in these collaborations and are not tamed, the artists do not have to adapt their thinking and processes to those of technology, business, and communication paradigms.

The international creator-in-residency programme 'STEAM Imaging' at Fraunhofer MEVIS, which is running for the fifth time in 2023, was designed to fuel contextualisation, self-efficacy, and diversity in STEM and digital medicine with a strong focus on science-inspired or science-backed artwork development and collaboration with future generations. Both self-determined

and intergenerational learning will gain increasing importance in the future. STEAM Imaging is a residency programme that brings together applied research, academia, and schools as the stakeholders of the medicine of the future.

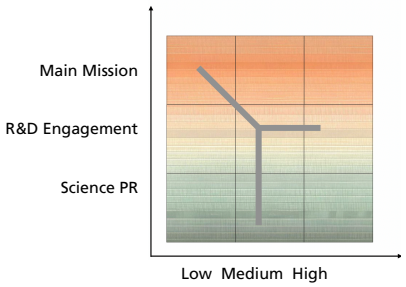
Contexts for learning and deep interdependent thinking are needed to discover meaningful answers in health care and scientific education in the future. In digital medicine, we face growing, complex challenges. Like all the real-world problems we face, including climate change, zoonotic diseases, and social inequality, solving them requires the integration of many disciplines. Despite everything that has been attempted to resolve divisions between disciplines, they remain problematic. Divisiveness is reflected in our educational institutions, professions, business models, funding structures, and industrial sectors. However, these divisions do not help solve complex issues sustainably. Still, questions remain. How much depth do we have to sacrifice in favour of interdisciplinary breadth? How deep an understanding of basic concepts in physics, biology, maths, or computer science is needed to apply them in a connected, sensible way? STEAM Imaging allows artists to exchange information intensively with scientists to critically examine current methods, developments, and research results in their works to create their own artwork. A key component of the programme is the shared encounter with school students. The art-and-research alliance enables prospective university students to approach scientific and technical topics from a new and unexpected perspective. It encourages them to engage with science, technology, and art in a self-determined, creative way. At the same time, non-tech-savvy audiences can also be engaged through the artworks exhibited.

In R&D institutions, including diverse perspectives is crucial for application-oriented developments. Multi- and transdisciplinary collaborations between artists and scientists create spaces for dialogue, which can lead to new ways of thinking about a particular subject matter. Tailored creator residencies can (within a guided process) enhance companies' or organisations' potential to adapt to social, environmental, and economic challenges. They can accelerate and enhance companies' outcomes (strategic engagement and communication, as well as R&D, services, and products) by reaching out to specific communities to fulfil an influential role in society. The goal is to contextualise a company's mission into a broader ecosystem of players that build emotionally positive and critical relationships with new technologies, developments, and products and services. The case study 'Whose Scalpel', an outcome from the artist-in-residence programme 'STEAM Imaging I', highlights how questions relevant to society and profoundly intricate, abstract, and serious subjects can be made more accessible to a broader audience. See case study 3.

STEM+ and Extracurricular Places of Learning: Integrating Artistic Approaches in Scientific Teaching and Learning with STEAM Workshops and Courses

Main Mission Integration: Low
R&D Engagement Integration: Medium to High
Science PR Integration: Medium

Realized Formats: STEAM workshops & courses, STEAM evenings with school student's family & friends, web-based learning tools, teaching material, incorporating real work tools, procedures, and real medical data.
Specific Aims: Engaging with R&D topics and tools, discussing current challenges in digital medicine. Experiential STEM+. Approaching digital medicine with artistic practices.



See case study 4

An integral part of the STEAM Imaging residency programme is the participatory STEAM courses and workshops held jointly with artists, students, and scientists. Artistic practice and thinking fuel the understanding of complex connections from multiple perspectives and act as translators between different stakeholders and communities of knowledge.

Being able to move successfully between various disciplines is a crucial competency for future education and innovation. STEAM courses can enhance multidisciplinary talents, inspire students to explore innovative educational models, and foster self-driven engagement with art, science, and technology, leading to the acquisition of multidisciplinary skills. These can expand students' creative practice and expression, which is beneficial for the future job market. At the core are participatory

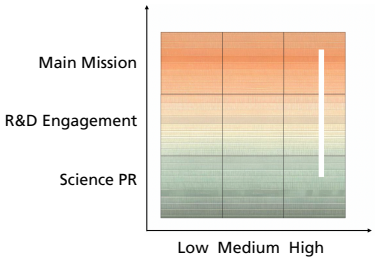
inquiries, which include both fundamental knowledge and free creative exploration to help understand a subject thoroughly. In addition to students, the internal workforce, supply chain partners, and even consumers can be engaged with this concept, tailored to their respective sectors, technologies, procedures, and tools. The idea behind such joint project-oriented creation and learning is not to impart a canon of knowledge. It serves to explore an issue as an example for learning how to autonomously develop innovative solutions, navigate new technologies, and facilitate critical discussions on these subjects. Interacting playfully with the core concepts, technologies, and tools (which are crucial for a specific product or service) allows companies and participants new avenues by which to view and deal with real-world questions and challenges. In STEAM courses, participants explore topics, theories, and real-life methods and practices. The courses are adaptable, cross-disciplinary, intergenerational platforms designed to address the implications of emerging technologies at an early stage. Through the joint development of the courses by staff and creatives, teacher and learner roles become fluid. The STEAM workshops and courses provide diverse role models and can assist school students in establishing valuable connections between education and career opportunities they may not have previously considered. Specifically, utilising current technologies and tools can be a true eye-opener for many participants.

Future generations will work with tools and in jobs that we may not even be aware of yet. Therefore, engaging schools, teachers, and communities in collaborative activities and channels that involve companies working alongside students is crucial. This collaborative approach allows for exploring issues, raising questions, and discovering answers that transcend disciplinary boundaries. A basic comprehension of new technologies should be part of everyone's education. Due to the speed of development, this can no longer be achieved by the adult generation alone. We require intergenerational dialogue, especially in education. How can communication and knowledge flow bi-directionally? STEAM courses and tools and creator residencies involving the young generation are potential solutions for addressing these challenges. See case study 4.

Contributing to Research and Developments: Artistic Practice Focusing on Programming Interfaces

Main Mission Integration: High
R&D Engagement Integration: High
Science PR Integration: High

Aspired Format: Tool for intuitive MRI sequence development
Specific aims: Make expert tools accessible to a diverse range of users



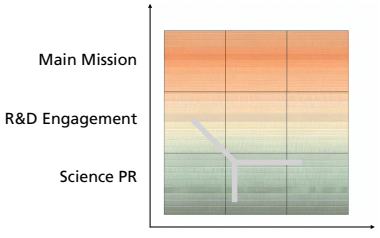
See case study 5

Currently, MEVIS scientists are seeking funding to integrate artistic practices within a research project focusing on programming interfaces to develop Magnetic Resonance Imaging (MRI) sequences broadening diverse access to expert tools and knowledge. In the future, the intuitive and user-friendly interface should also enable third-party medical staff and research clinicians to explore new imaging ideas quickly and efficiently. In addition, this expert domain will be opened to further professions and other usage contexts, such as for artwork development. Clinical staff, teachers, students, and creatives will have the opportunity to explore sequence development ideas using a basic version of the expert tools. This shift enables a more open, creative approach to MR sequence development, opens up broad access and knowledge transfer to society, and, ideally, pushes the limits of what can be achieved in medical imaging, enhancing options for patient examinations. See case study 5.

Supporting Creators in Scientifically Inspired or Backed Artwork Development

Main Mission Integration: None
R&D Engagement Integration: Low
Science PR Integration: Medium to High

Realized Formats: Audio-Immersive and VR Experiences
Specific Aims: Raising awareness about possibilities in digital medicine. Looking at digital medicine from an artistic perspective. Bringing engaging artworks to new public places, reaching broader audiences.



See case study 6

In addition to their artistically oriented works, the MEVIS scientists also provide support or consultation to national and international artists and engage in collaborative projects. R&D partnerships for artwork development are an excellent way to collaborate with artists. The scientists provide access to expert tools and knowledge and process and prepare medical data; mutual knowledge exchange allows the creation of bridges between the sectors of artwork development and applied research in digital medicine. One example of this is the collaboration between Fraunhofer MEVIS and the artist collective Marshmallow Laser Feast from London, resulting in the artworks 'The Tides Within Us' and 'EVOLVER'.

This collaboration enabled the creation of a work of beauty. The autonomy of the artists – refraining from imposing their thinking onto the processes or approaches of handling technologies and R&D in the usual way – was crucial. Simultaneously, it was essential for the artists to be attentive without corrupting the precise and in-depth knowledge of the scientists. In the field of medical technology, researchers are accustomed to working in inter-, multi-, or transdisciplinary ways. Collaborating with artists offers diverse avenues for exploring and presenting scientific data and topics. The artists expand avenues for scientists and, ultimately, the wider public to perceive and address phenomena concerning the human body in the tangible realm, along with the associated questions and challenges they present. See case study 6.

SELECTED SCI-ART CASE STUDIES AT FRAUNHOFER MEVIS

1 'The Beauty of Blood Flow Analysis', an immersive audio-visual 2D, stereoscopic 3D, and hemispheric installation by Fraunhofer MEVIS, conveys emerging possibilities for gaining knowledge and making predictions about the human body

'Great visualisation, sophisticated, cutting edge technologies, and fore and foremost clinical valuable information.'
Dirk Simon, Siemens Digital Factory

Artistic, spacial, immersive experiences enable emotional, positive engagement with severe health topics and new developments in digital medicine. MEVIS scientists, somewhat like artists themselves, creatively applied diagnostic technology to create 'The Beauty of Blood Flow Analysis'. The short piece is based on new research and technologies in digital medicine. It conveys emerging possibilities for gaining knowledge and making predictions about the human body. They strictly and purposefully limited themselves to real medical data used for diagnostics, treatment planning, and monitoring. The project's aim was to reach a broader, not necessarily tech-affine, audience on an emotional level. In developing software assistant tools for clinical routines and producing exhibits and moving images for science engagement, the MEVIS team witnessed the enormous beauty of blood flow. They naturally wanted to stimulate discussion around treating severe diseases, for which they are developing new procedures and technologies, thus introducing them to a societal, cultural world. The project allows the audience to witness the beauty of the swirling flow of blood in the heart and gives an idea of the awe-inspiring steadiness of the heartbeat. By looking at the flowing blood, various diseases can be detected; for example, turbulent vortices indicate a malfunction of the heart valve. Software assistant tools help clinicians to navigate and integrate this complex information. Medical data is a sensitive topic; finding a line in the technical production that still provides enough anchors for discussing real-world clinical problems, as well as providing enough space for awe-inspiring artistic visuals, was a central challenge for the scientists. While retaining this authenticity through Sci-Art, the distance between the viewer and the scientific medical work is bridged. The project 'Beauty of Blood Flow Analysis' has been the starting point for further explorations at the institute together with artists. The goal is to add educational programmes to scientifically informed art installations and engage diverse audiences in the wonders of the human body and the constructive possibilities of new technologies. The awarded work, 'The Beauty of Blood Flow Analysis', is shown in international venues in broad contexts, such as conferences on healthcare technology, in science centres, and at science, tech, and art festivals. (See addendum 1.1).

2 'Digital Medicine, Arts, and STEAM: Before Us Lies ETERNERDY', an immersive audio-visual 2D and stereoscopic 3D installation, on a technical, scientific, and mathematical understanding of the human body

'The ETERNERDY, coined from the idea of "The Eternal Nerd", is far more than a mere visual spectacle. It is a symbolic testament to the limitless bounds of human curiosity. Not simply a study of art or science, ETERNERDY delves into the essence of human creativity and the quest for knowledge. It unravels the complexities of digital medical data, and brings intricate discussions on severe diseases and new technological possibilities to diverse audiences. By leveraging art as a medium, this film demystifies severe health topics and encourages public engagement.'
Ina Conradi, Artist, Associate Professor, The Nanyang Technological University

'Digital Medicine, Arts, and STEAM: Before Us Lies ETERNERDY' by Fraunhofer MEVIS scientists, gives insights into several ways to interpret the human body with different kinds of data acquisition and processing. Understanding and negotiating complex issues in digital medicine requires expertise, time, and dedication. But who is developing new technological possibilities, telling their stories, and shaping the medical future? The immersive installation is based on reflections about researchers and their curiosity and creativity in dealing with issues that can only be penetrated through technical, scientific, and mathematical understanding. The installation shows a floating human body in a space-like environment. Accompanied by spheric vocals, it looks into the body and an organ down to a layer of tissue that, when magnified, reveals itself as the space environment with star-like lights in which the body floats. The project shows different scales of the human body: from digitised microscopic lymphoma tissue examined with the molecular cytogenetic technique fluorescent in situ hybridisation (that detects abnormal changes in DNA) to 3D reconstructions of two vessel systems of a liver (for patient-individual surgery planning) to a whole-body MRI. Fraunhofer MEVIS researches and develops MR sequences for clinical practice, software for automatic and precise analysis of tissue sections for digital pathology, and is a pioneer in combining and analysing medical data for better information integration and decision support for medical professionals. The internationally awarded work premiered simultaneously in 2D and stereoscopic 3D, bridging audiences in Austria and Singapore on-site with a live Q&A session with the scientists and artists involved. It was exhibited at various venues and festivals at the intersection of science, art, and technology. (See addendum 2.1).

3 'Whose Scalpel', a live performance integrating developed sound devices, addresses questions around decision support for medical professionals: what do humans lose when the computer takes charge in the operating room?

'Linking science, technology, and art holds great potential for addressing our social, environmental, and economic challenges in Europe. 'STEAM Imaging' is a programme that has been unleashing this power for years, creating an international lighthouse project focused on knowledge transfer and learning through art. We need more programmes like this.'
Veronika Liebl, Managing Director Festival Prix Exhibitions, Ars Electronica

Do new developments such as artificial intelligence offer opportunities and motivation, or will humans become the losers of progress? 'Whose Scalpel' by artist Yen Tzu Chang addresses the complexity of art and medicine and possible consequences for our society. It asks what human beings lose when the computer takes over. The accompanying installation is based on a supersized 3D-printed model of the artist's heart, equipped with sound generators. During the performance, Yen Tzu Chang acted as a 'surgeon', placing a bypass with the help of cables – presumably guided by artificial intelligence. Through the almost complete darkness, an intense, unsettling backdrop is created, which only conciliates at the end of the performance.' Whose Scalpel' was created as part of 'STEAM Imaging I,' a residency programme to link science, technology, and mathematics with the world of art. The project combined computational medicine with STEM issues, sound art, and ethical discussions. During her stay at the institute in Bremen, Yen Tzu Chang learned how to use a software platform for processing medical image data (MeVisLab). MR imaging and MeVisLab were also central topics of the STEAM school student workshops, which are an integral part of the residency programme. The aim was to break down barriers between the disciplines and to explore flexible forms of learning and collaboration. 'Whose Scalpel' was exhibited at various international venues and referred to in expert publications. In October 2023, 'Whose Scalpel 2.0' will premiere, enhancing the installation and integrating a dancer into the performance. (See addendum 3.1).

4 'Inside Insight', a web-based interactive STEAM application to create an understanding of the value of physics, mathematics, and computer science for medical imaging

'I like to use Inside Insight in computer science classes as a treat at the end of the semester. Our learners are eager for real-world topics. They are fascinated by the medical images with which they can work interactively, guided by experts. It is crucial to convey how important it can be for all of us to use algorithms intelligently and that their development is based on interdisciplinary expert knowledge.'
Susanne Pedersen, teacher for computer science and mathematics, Gymnasium Ulricianum Aurich, Germany

The tool is a basis for getting the basics of medical imaging and an idea of the possibilities of 'MeVisLab,' a rapid-prototyping platform that allows medical data processing. Usually, 'MeVisLab' is used by researchers and developers to build assistant tools for clinicians. The web-based tool 'Inside Insight' is created from materials and prepared use cases scientists have developed over the years to show possibilities of applications in the medical routine. MEVIS scientists aimed to make real-world tools (developed with' MeVisLab') and explanatory materials easily accessible in an explorative and creative way. Users simply log in via a web browser. The tool encourages to explore medical images creatively, thereby playing with STEM knowledge. It is completed with explanatory material, enhanced by an artist, and audio files. 'Inside Insight' helps users understand that questions about the body can be answered by mathematics, physics, and computer science. The tool

was nominated as a finalist for Best Educational Media at an international science film festival and is in regular use in numerous workshops and courses in the field of STEM teaching and medicine and art and technology alike. (See addendum 4.1).

5 'gammaSTAR' and 'gammaSTAR element'

Magnetic resonance imaging is an essential medical diagnostic tool. The image acquisition process, unlike in X-ray, is complex and requires special software to control the MRI sequences. Traditionally, developing such sequences has been the domain of a small group of highly specialised software engineers. With gammaSTAR, MEVIS scientists will enable a broader range of players to develop MR sequences – vendor independent - for multiple scanners from various manufacturers; gammaSTAR will expand the possibilities for exploration and experimentation in developing MR sequences, in addition to established procedures and protocols.

6 'The Tides within Us', an immersive interactive audio-visual installation, and 'EVOLVER', a VR experience by artist collective Marshmallow Laser Feast on where the human body begins and where it ends.

'A mesmerising representation of the human body… It's a stunning work of exquisite educational power.' Cool Hunting

Stunning interactive screens allow the audience to explore the human ecosystem. 'The world flows into you, and you flow into the world', describes artistic director Barnaby Steel, Co-Founder of Marshmallow Laser Feast. For the project, STEM experts had to find ways to give the artists medical anatomical and flow data in a technically consistent form from their perspective, which was different to the way these data are acquired and processed in the medical routine. The scientists had to create an understanding of what it represents and where the limits are, for instance, in accuracy and resolution. This collaboration has opened new ways of seeing and experiencing the human body. Together, the partnership aims to offer new platforms for experiential and embodied learning. The project's ultimate goal is to change the way people learn and think about themselves in relation to the environment. Where does their human body begin, and where does it end? 'Many different dynamic and complex processes occur within the human body every second. Gaining a deeper understanding of the details and variations of those processes helps us to understand diseases and optimize therapies. Measurement and imaging methods are utilised and developed every day. Even if those sensors are only capable of capturing a fraction of these processes, they generate a lot of complex data. To gain knowledge from this data, it needs to be understood and analyzed by experts. Visualization of this medical data is an important step in understanding. 'The Tides Within Us' is also a form of medical visualization, but with different goals and a much broader audience, who might not be medical experts', explains Matthias Günther, Deputy Institute Director, Head of MR Physics, Fraunhofer MEVIS. The experts were pushed to rethink the limitations of MR acquisition and medical data preparation and accessibility and providing meta information for non-MR scientists. Additionally, software architects gained a further understanding of tools used within the artistic community, such as cross-platform game engines and 3D animation software, and created bridges and workflows between these tools. The art also provides a way to increase public and science engagement and appreciation of science and research. The work was internationally presented at art galleries and scientific conferences alike and won an industry award for best new media format and several honorary mentions as a unique and pioneering artwork. (See addendum 6.1).

ADDENDA: SELECTED HIGHLIGHTS OF EXHIBITIONS, SCREENINGS, PRESENTATIONS, AND PERFORMANCES

1.1. 'The Beauty of Blood Flow Analysis'
Screened at: Sparks! at CERN Future Technology for Health, 2022 (CH); Bright Festival Connect, 2020, Leipzig (DE); 9th International Festival of Science Visualization IFSV Dome Fest in Tokyo, 2019 (JP); STEAM art, Global LEAD Event World Tour New York City, Stanford LEAD Program, 2019 (US); 12th Fulldome Festival, 2018, Jena (DE); among others. Selected Highlights: 'Beauty of Blood Flow' was nominated as a Finalist at Falling Walls Science Breakthroughs of the Year 2022 in Art and Science, Berlin (DE). The Sci-Art work was recognized by the scientific documentary industry and won the 2018 Industry Award for Best Immersive Media at the Raw Science Film Festival in California (US). The work was nominated at the 12th Fulldome Festival, 2018, Jena (DE).
Credits: Directors and Science & Art Producer: Bianka Hofmann, Alexander Köhn, Mathias Neugebauer; Scientific Advisor: Anja Hennemuth; Sound: David Black; Fraunhofer MEVIS (DE)

2.1. 'Digital Medicine, Arts, and STEAM: Before Us Lies ETERNERDY'
Screened at Bright Festival Connect 2020, Leipzig (DE); CITY OF QUANTIFIED VISIONS, 2019 (SG), Raw Science Film Festival, 2019 (US), Ars Electronica Festival, 2018 Linz (A), Media Art Nexus NTU, Singapore, 2018 (SG); among others. Selected Highlights: The work was recognized by the scientific documentary industry and won the Industry Award for Best Infographic at the Raw Science Film Festival, 2019, California (US). The work premiered simultaneously at the Deep Space 8K at the Ars Electronica Center & Festival 2018 (AT) and at the Media Art Nexus (MAN) at Nanyang Technological University Singapore (SG) with a life connection and Q&A with audiences.
Credits: Directors and Science & Art Producer: Bianka Hofmann, Alexander Köhn, Mathias Neugebauer; Scientific Advice: Henning Höfener, Andre Homeyer; Sound: David Black; Fraunhofer MEVIS (DE). In cooperation with Ina Conradi and Mark Chavez, Media Art Nexus, Nanyang Technological University Singapore (SG); Fluorescent in situ hybridization (FISH) data kindly provided by ZytoVision; special thanks to Volker Diehl, Jochen Hirsch, Julian Haase, and Dagmar Weiß

3.1. 'Whose Scalpel'
Exhibited & performed at Science and Art in Dialog, 2018, Berlin (DE); FRAMELESS16, MUG at the Einstein, 2018, München (DE); Music Hackspace, Somerset House Studios, 2018, London (UK); Ars Electronica Festival, 2017, Linz (AT); among others. Selected Highlights: Hofmann, Bianka. (2019). Linking Science and Technology with Arts and the Next Generation—The Experimental Artist Residency "STEAM Imaging." Leonardo. 54. 1-10. 10.1162/ leon_a_01792. Schnugg, Claudia. (2019). Creating ArtScience Collaboration: Bringing Value to Organizations. 10.1007/978-3-030- 04549-4. Ed. Ars Electronica Center Linz, The Practice of Art & Science, The European Digital Art and Science Network (Hatje Cantz, 2017), pp. 50–55. 'STEAM Imaging I' was hosted by Fraunhofer MEVIS (DE) and Ars Electronica (AT) in collaboration with the International Fraunhofer Talent School Bremen; realized within the European Digital Art & Science Network

Credits: Artist & Sound & Performance: Yen Tzu Chang (TW), Fraunhofer MEVIS team: Bianka Hofmann, Sabrina Tölken (née Haase), Alexander Köhn, David Black. Ars Electronica team: Veronika Liebl, Jessica Galirow, Maria Pfeifer, Peter Freudling, Erwin Reitboeck. Technical support of medical images: Alexander Köhn. Technical support for 3D models and printing: Peter Freudling, Erwin Reitboeck, Benjamin Krux. Special thanks: Interface culture, Fabricio Lamoncha Martinez, Jie Ting Jiang, Yin-Wen Lin

4.1. 'Inside Insight'

The STEAM application is in regular use in numerous workshops and courses; it was used in the course 'Art and Medicine' at Paris Lodron Universität Salzburg PLUS & Mozarteum 2021 (AT), at Sci-Art NanoLab Summer School at UCLA in 2018 (US), among many other occasions. Selected Highlights: Schnugg, Claudia. (2020). Evaluation STEAM Imaging III: Art Meets Medical Research Online STEAM course 'Inside Out:10 STEAM Evenings' 10.13140/ RG.2.2.27760.38409. The STEAM application 'Inside Insight' was nominated as Finalist Best Educational Media 2018 at the Raw Science Film Festival, California (US) and in use within the graduate course by Prof. Roger Malina at UT Dallas, 2018, Special Topics in Arts Technology and Emerging Communication – Art, Health, and Medicine (US). Schnugg, Claudia. (2017). STEAM Imaging: Art Meets Medical Research: Evaluation Summary. 10.13140/ RG.2.2.11923.58403.

Credits: Fraunhofer MEVIS, with special thanks to the Young Talent Team. Realization: Bianka Hofmann, Alexander Köhn, Sabrina Tölken; in cooperation with artist Hannah Klatt

6.1. 'The Tides within Us' and 'EVOLVER'

'EVOLVER' was presented with Fraunhofer MEVIS as research partner at MUSEUM WAVE in 2023 in Seoul (KR), where Squid Game's Lee Jung-Jae joins Cate Blanchett in new voiceover for 'EVOLVER: A Virtual Reality Journey Of Life and Breath;' at the 2022 Geneva International Film Festival (CH), with the European Premiere of 'EVOLVER;' at the 2022 Tribeca Festival (US) 'EVOLVER – A Virtual Reality Journey of Life and Breath.' Presented at the launch program of The Reel Store, UK's first permanent immersive digital art gallery, opened in Coventry in 2022 (UK); SIGGRAPH Asia 2021 Art Galleries, 2021 (JP); Coventry City of Culture (co-commissioned and co-produced by Coventry City of Culture Trust and York Mediale, 2021); the Human Nature Exhibition at York Art Gallery, 2020/21; at Ars Electronica Festival 2020: A behind-the-scenes look and Guided Online Tour to the MR Lab by artist and scientists involved; an introduction to the artwork was given at First Star Scholars UK, University of Winchester 2021 by artist Barnaby Steel, followed by a hands-on online workshop from scientists on medical imaging based on the tool 'Inside Insight.' Selected Highlights: 'EVOLVER' received the Jury Mention for Storyscapes Award at Tribeca Festival 2022. 'The Tides Within Us' won the Industry Award for Best New Media Format at the Raw Science Film Festival, 2022 (US). The work found its way into the compelling book 'Imagining Imaging' by radiologist Michael R. Jackson. 'The Tides Within Us' received an Honorary Mention at the STARTS Prize 2021 as a unique and pioneering artwork.

Credits: Concept: Marshmallow Laser Feast. Directed by: Barnaby Steel, Ersin Han Ersin, Robin McNicholas. In collaboration with Natan Sinigaglia. Scientific Partner: Fraunhofer Institute for Digital Medicine MEVIS. The Tides Within Us was co-commissioned by York Museums Trust, Mediale and Coventry City of Culture. Funded by Arts Council England.

Keywords: artiscience, artist's residence; artistic practice; co-creation, computer graphics, creator's residence; digital transformation, diversity; higher education; human resource development; innovation; interaction, knowledge transfer to the community; learning tool; media art; multidisciplinary, production; science communication, self-efficacy; skill development; sound art; participatory, Sci-Art; STEAM; experiential STEM; STEM+; strategic engagement; technology contextualization; transdisciplinary, visualisation

I thank the curious and courageous scientists from Fraunhofer MEVIS' R&D Engagement – doers, explorers, contributors – and the cooperating artists who made these explorations and projects possible. Many thanks to David Black for editing my English article.