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Make unseen seen:

SciArt as a tool to interlink science and art

Master's Thesis
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"He to whom Nature begins to reveal her open secret will feel an irresistible yearning for her most worthy interpreter, Art." – Goethe.

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Abstract

Art and Science are usually thought to be opposite to each other, with their own separate history, philosophy and practices. But if we investigate deeply both faculty, they have much deeper connections that have intrigued philosophers, artists, scientists and laymen through centuries. Philosophically oriented literature highlights many similarities between art and science, such as a shared need to understand the world we live in and both need the same kind of creativity and innovation. These connections have not been investigated experimentally with artists, who have a strong interest for science. The hypothesis or research question for this thesis is: Can these mutual similarities be experienced and found by making art from scientific topics?

Art inspired by the world of science is called SciArt (ScienceArt) and is the artistic trend applied in this research. This original art trend has been gaining popularity over the last few decades, is relatively well known globally and is a perfect context for experiencing art and science at the same time. SciArt is used widely in science education, and one well-known subcategory, scientific illustration, has existed for several centuries already.

For this research, a SciArt workshop was conducted that concentrated on scientific topics in microscopy physics, where participants practised art-based methods in the context of science and experienced both art-making and learning scientific phenomena at the same time. Qualitative nature art-based research and action-based art research methods were used in the analysis part. Participants, who were art students, experienced this deeper connection between Art and Science, and they also found common factors between both professions, artists and scientists.

Results from this thesis can be exploited in many ways. To develop SciArt workshops for different uses, such as galleries; for educational purposes, from elementary schools to universities, to teach scientific illustrations; and to promote science and art or SciArt itself.

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1. Introduction

In the art world, science and its findings have inspired artwork throughout history, especially in the last century with the rise of modern art (Marcolli, 2020). Even a new art trend called SciArt (**Science and Art**) has emerged in the last couple of decades, which takes inspiration from the world of science. Usually, these two faculties are considered opposite to each other, with no similarities or interlinking, but they have a lot in common. Such as creativity, finding new understanding and meaning, and intuition, just to name a few (Heylighen & Petrović, 2020; Ghisleni et al., 2025). Philosophers have also debated the connections between art and science for hundreds of years (Shlain, 2007). It is well known that, especially among great academic thinkers and philosophers, many have found surprisingly many similarities between Art and Science, such as an attitude toward observing one's surroundings or seeking to understand the meaning of life. Names like Aristotle and Goethe are among the best-known figures; scientists like A. Einstein and R. Feynman were also keen followers of art and have found similarities between art and science. But so far, this close relationship has not been investigated experimentally in art workshops among participants, at least based largely on my own literature review. Philosophical discussion and other academic material about this philosophical interlinking is vast; however, to keep this thesis compact, we discuss philosophical points of view only briefly in this thesis in the next chapter.

One of the aims of this master's thesis is to give new experimental insight into this topic (similarities between art and science) drawn from the experiences of art-workshop participants. I don't seek any validation or proof that similarities are real. Still, I like to see if participants find these connections themselves by making art and gain more understanding about these similarities between two opposites. Naturally, because I have a background in science and art, I have been personally interested in these connections for decades and find a lot of common factors in science and art-making. I also found in this research that the SciArt workshop experience can give a feeling of understanding phenomena that are too small to observe and have attributes that challenge our normal way of seeing the physical world. During the analysis stage, one minor research question arises, which I think is important to include in this thesis. It is can SciArt workshops be a practical way to teach scientific illustration in future, or can we use them on other occasions, like interventions in

industrial or technology organisations? Reasons for that will be answered in the next chapters.

In other words, I study applied visual art activities (and applications) in the context of natural sciences. The art-based methods that are used in this work are well known in socially engaged art or communal art research fields already, and one of the aims of this study is to give new information about how they work in new contexts, for example, physics or other natural sciences. I am interested in investigating whether art workshop participants can have a positive experience with science-oriented materials and get inspired and feel empowered during the working process. One art workshop series, themed "SciArt," was held in December 2022. A follow-up exhibition to the workshop was held at the end of March 2023 (which is also an artistic part of this thesis). Findings and results from this research are presented in this work with criticism. Research methods in this thesis work are categorised as Art-Based Action Research methodology or ABAR (Jokela & Huhmarniemi, 2018) and art-based research or ABR (Leavy, 2015). Scientific topics for this workshop were elementary particle physics and its interactions. As a microscopic-level physics that we can't see directly, it gives a lot of freedom for independent visualisations. Thus, the theme for the workshop was making the phenomenon of unseen physics visible.

It is well known that art-based methods are a valuable aid in learning situations. Art-based methods are widely used in mathematical contexts nowadays to help students improve their performance (Fenyvesi et al., 2023). One good example is STEAM pedagogy (SciArt Project Consortium, 2024). I think that many science fields, like chemistry, biology and physics, can benefit from art-based methods in students' learning processes in the same way. With that in mind, it's not a big jump from the mathematics field to physics as a new testing ground for the same kind of artistic methods. I hope the results of the thesis can help educational progress in natural science as well.

I have a solid background in natural sciences and industrial technologies. As a physics student and later as a researcher, I found that very often I had to lean on my own imagination and sometimes make complex visualisations about the topics at hand. So, to understand physics, you need something more than calculus. Many times, it is commonly thought that physics and chemistry are about formulas that can lead to calculated results or predictions. That is only partially true. At the beginning of the scientific process, one has to get familiar with several abstract parameters and their complex interaction networks. In the end, and this is my own impression as a physicist, mathematical formulas are, in the best cases, very crude attempts to express the physical world or existence. In many ways, participants in this

workshop visualised the same phenomena that many scientists do. I think that this experience helped artists to find similarities between professions and give a glimpse into scientists' work. Artists jump into scientists' boots or role for a while, so to speak.

Different kinds of visualisation techniques and technologies have been established during recent decades, thanks to programs and computers' evolution. One worth mentioning was the popular chaos theory boom during the 90s, which is remembered for colourful computer pictures (Kappraff, 1999). Of course, scientists used graphic illustration programs to visualise results; in some sense, computer visualisation has established itself as a useful tool. These scientific illustration programs can be used to make art by an artist or scientist. But I think those illustration programs are based mostly on formulas and other restrictive rules and numerical constraints. They don't give creative freedom like normal "*Paint and Brush*" methods. Artistic methods are free from scientific laws and customs, in that sense. Thus, artistic methods can give scientists more freedom to express their ideas. Many physical theories have a lot of abstract concepts that sometimes require a lot of intuitive work and mental visualisations. Modern physical theories, like hologram models, general relativity or quantum field theories, are well-known popular theories that need some kind of imagination. These "*scientists' mental pictures*" would be very interesting to see if they would transfer to material art, like paintings, sculptures, videos, etc. I often think that artists can learn different kinds of visualisation attitudes from physicians, but, most importantly, I think that art-based workshops should be designed by artists for scientists, too. SciArt workshops for natural scientists- why not? Perhaps as an outcome of this thesis.

This thesis leans heavily on the idea that everyone can visualise these physical phenomena or complex parameters, if they are interested. That idea is also based on my own experience as a physicist. Of course, an open mind and some degree of playfulness are usually needed as well. One core idea for this SciArt workshop was also to provide safe areas for participants to experience empowerment and confidence in the highly theoretical and speculative area of physics. The target group in this research is adults, and I would like to continue to develop new art workshops and activities with and for mature people. Naturally, the results of this thesis can be applied and used in schools and educational research, but at least for adults, there are not so many possibilities to learn physics on their own. I would also like to see in future that the SciArt workshop would spread to other universities that have no art courses in their curriculum, like universities of technology or universities of applied science.

I want to point out that the aim is not to test are persons academic abilities in physics have increased or not. It is very important to recognise that the participant feels he is learning something new during the process. One aim is to find out if other participants' artwork further helps that feeling also. To get inspired and to get more deeply interested in natural science is more valuable than calculus abilities. Can this kind of art-based work give a more respectful attitude towards nature and its phenomena? It is a valid point to make in our time. Another interesting question is that can this kind workshops can give encouragement to participants to believe his abilities to study science more in future. So often it is believed (based on personal conversations with people who are interested in physics) that only people who have a long study history or some other kind of “initiation” to complex theories can understand their concepts. That’s not true; everyone can understand something if they are interested. Of course, someone must study for years to work as a scientist and to refine existing theories, but you can certainly understand it to some extent.

Art that has been made in this science-art workshop and exhibition can be categorised as science-art or SciArt. It is an art trend that takes inspiration from the world of science. Even though this movement is very popular nowadays (SciArt Initiative, 2025), it is well-known that artists have taken inspiration from science, especially during the last hundred years (Marcolli, 2020). In this work, SciArt is the name I choose to use for this art trend. This art movement incorporates scientific themes in art-making, like scientific results, theories, research methods, science history and many other science-world topics as a source of inspiration. SciArt can have several themes or purposes in its curriculum. One is making invisible objects too small for our seeing abilities visible. A very typical art practice for this is photography. Incorporated with microscopy, photography can show us miracles of nature that are invisible to our naked eyes. Very good books about making microscopic phenomena visible are F. Frankel's book “Envision Science” (Frankel, 2002) and J. Challoner's “Seeing Science” (Challoner, 2022).

One of the main aims is to explore whether physics and other natural sciences can be an inspirational source for artmaking. Especially in the BioArt field, which is a subdivision of SciArt, artists search for inspiration from the biosphere. Even let natural elements like wind and sun radiation do the creation part. In the same way, we can think that physical phenomena can give inspiration to artists or people to be creative and find interesting ideas for artwork. The science field has numerous measurement or research methods that can be easily adapted to artmaking. Also, for environmental or ecological reasons, many artists have incorporated science-based materials into critical art forms as a statement to preserve

nature. These are only a couple of examples of what SciArt can be, and, in my opinion, the possibilities for how to use it and what SciArt can be in the future have just begun to open up to artists and designers. Thus, this art trend is in the development stage. I must point out that SciArt, as a term or art trend, is surprisingly unknown to the Finnish art world, so I hope this thesis and its results can help to promote this very original art trend.

These study findings can be used in different ways in the future. In the educational field, possibilities to find new tools for teaching are obvious, but also something new to the field of popularisation of science. SciArt workshops can be modified for different purposes (like courses, one-day workshops, or use in art galleries) and social groups, like artists, designers, engineers, art enthusiasts, and of course, scientists. SciArt and scientific illustration can be fields that some artists can explore more and find some, or even a regular income in future. So many artists are striving economically nowadays. The science community needs artists to make results visible and easy to understand to people outside the scientific community. I found out that this trend is growing globally (Nature, 2021). I also hope that this research helps to spread information about SciArt to artists, scientists and other people.

The outline of this thesis follows roughly the following protocol. In the next chapter, Chapter **2. SciArt as an Art-Trend**, we discuss more about SciArt, its definition, terminology and some information about its history. Some examples where art and science are united are also presented in this chapter, such as scientific illustration. It must be pointed out that SciArt is a very wide concept and can take a lot of sub-themes in its curriculum. In this chapter, we concentrate on only those themes that are relevant to this thesis. Philosophical and historical perspectives will also be presented shortly, and some art trends combine math or science with art. Also, artists' possibilities to work as a SciArt specialist are discussed.

In the follow-up Chapter **3. Art-based research and methodology** have discussions about the theory of research, an introduction to research methods and other factors that are important. Research questions are presented again in this chapter, with a discussion of motivations and ideas behind them. In this chapter, is reviewed couple of interesting research that crosslink with the themes of this thesis are reviewed. Also, a critical view of the literature is discussed in this chapter.

In Chapter **4. Workshop** procedures are discussed in great detail from the planning stage to the end of the workshop. I chose to review this workshop process in detail because of the nature of the topics and, most importantly, for someone who is conducting SciArt activities in future. Especially how to choose the scientific part and what to consider. In this chapter,

the scientific part dealing with physical topics is also presented. The basic idea is to present the level of lecturing, but also a collection of those phenomena that can be seen in artworks done in the workshop and in the exhibition. I hope this physical part can give more insight into the topics.

Chapter **5. Results** are dedicated to a deeper analysis of the workshop process from the early stage of planning to the exhibition. Results are presented with criticism and with a comparative analysis with the literature. Also, I present some minor results I found after analysing all the feedback and pictures. I also write a little bit about my own impression as a physicist concerning art made in this process. Some selected pictures of artwork are in this chapter. Also, I discuss what I learned as a workshop facilitator and as a natural scientist. I discuss the workshop process (from planning to the last exhibition) a little bit more than is necessary, because of the nature of the topics, but also to analyse the workshop model for future use for a different purpose.

In the last chapter, **6. Conclusion**, I will summarise the whole workshop process, results, finding. I present several improvements for SciArt workshops for anyone planning to design a similar art action in the future. Some new research questions are also presented. In many ways, these workshops participant we standard students (by educational history) who can also find outside art university classes, so suggestions are made on where this kind of workshop can be organised. Additionally, I present several development ideas for future courses, like Scientific illustrations for different educational systems or schools.

2.SciArt as an Art-trend

2.1 Terminology: Science-art or SciArt or something else

Science-art, ArtScience or SciArt, as its own art form or art-trend, is relatively new. So, definitions about SciArt are not established yet, nor are interpretations about what SciArt is or what kind of art it is. Phillip Ball (Ball & Ede, 2017) stated very aptly (from the situation),

“...There is not even clear agreement about what to call the phenomenon.”

In this thesis, as it is most often understood also in modern literature, its definition can be (Fleerackers et al., 2022)

“Art trend that takes inspiration from science areas”.

Or like

“SciArt is the joining of science and art” (Emergin Creatives of Science, 2024).

In this context, inspiration for art-making can be almost anything, from research methods, scientific theories and results or the culture around the science community. I have found when doing research about a topic that SciArt can vary from illustrative to abstract with any media possible. Sometimes categorisation can be difficult with certain artworks; are they SciArt or not? This question is not relevant to this thesis, but it should be remembered that interpretation can vary in different contexts. SciArt as a term was introduced in the late 1960s by artist and physicist Bern Porter (Sleigh & Craske, 2017), although it started to establish last few decades as a growing art trend. Also, as a relatively new research area, there is no coherent or established research culture. Camilla Røstvik (Røstvik, 2016) aptly in his doctor dissertations

“Because of its short history and the institutional nature of its origins, critical literature about SciArt is lacking”

That can be seen clearly by the lack of scholarly-oriented textbooks and the very fragmented research papers on the subject. When I was searching for research information for this research, some material was collected from internet sites and magazine articles. Although some good books can be found, they are more of a general nature. Some books can be found with next reference (Malina, 2016).

Based on information collected for this work from recent media releases like magazines or SciArt organisations' webpages, SciArt is clearly established as a leading notation nowadays. In this thesis, SciArt is used as a term going forward. Other notations can find from reference, like (Huhmarniemi, 2011) and (Ball & Ede, 2017). In this context, we must clarify that the term Sci-Fi or Science Fiction means complete other style of art, and it has very little to do with SciArt. Even if art is based on the futurology research tradition (which is a real academic science area), it is SciArt, not Sci-Fi. Most of SciArt is based in natural sciences, but we must always remember that there is a lot of science that can be inspirational to art projects, like futurology, sociology, psychology, economics and history. For example, can we consider gastronomy, with incorporate recent molecular chemistry findings, as science nowadays? See reference (Harmon, 2024). Can an artistically well-designed plate of food in a three-Michelin-star restaurant be a SciArt work somehow? Yes, at least I think so.

Many art trends are also sometimes associated with SciArt. Like Tech Art or Technology-Art, Math Art or Optical Art. Strictly speaking, are they always actually drawing inspiration from science? Or more from new technology or playing with optical phenomena? Also, it looks like SciArt appears more like an umbrella term that has, of course, an art trend inside, but also scientific illustration, an art-educational dimension like STEAM pedagogy, Scientific communication, Bio-art, activist environmental art, and all kinds of art activities touching science in some way.

As stated before, visually, philosophically, or artistically, SciArt can take a multitude of roads. So, it's not necessary or useful to make a summary of the different roads here, but I would recommend reading Stephen Wilson's "Art + Science Now" book (Wilson, 2010). To me, it's one of the best books about multiple aspects of SciArt.

2.2 Connections between Science and Art

At first glance, art and science seem like separate faculties, opposites to one another, with no similarities or connections. But they have a lot of commonalities and similarities on a practical and philosophical level. That relationship between art and science has been a very interesting theme for philosophers, artists, scientists and laymen over the last centuries. Art and Science have been closely integrated during Renaissance times but have disintegrated or evolved into their own ways. Some researchers see SciArt as a movement to bring these two polarities closer to each other (Heylighen & Petrović, 2020). This subject can be approached from many angles. One is that we need to investigate the motivations of artists and scientists, because art and science are outcomes of the work of both professions. L. Shlain (2007) wrote about similarities

“Revolutionary art and visionary physics are both investigations into the nature of reality.”

F. Heylighen (2020) stated the motivations of artists and scientists

“Both scientists and artists first of all seek to make sense of the phenomena that surround us, exploring different meanings, approaches and tools in doing so.”

Art and Science have a lot in common at the cognitive level. Nicolas Bulot (2017) summarises Catherine Elgin's (1993) seminal statement aptly.

“The arts and the sciences perform many of the same cognitive functions, both serving to advance understanding”.

I conduct research on the literature about the philosophical connection between art and science; the material is naturally vast. Also, it's good to remember that there are academic opinions that art and science don't have so much in common. One very frequently seen opinion is *“the Two Cultures”* view by C. P. Snow (Snow, 1993) and Bulot et al. (2017). Because I am more interested in this thesis, about people's (workshop participants') own findings about the subject, we don't go deeper into these philosophical issues. In this thesis,

I am just “*making an assumption*” that Art and Science have something in common and that the work of scientists and artists has similarities, but not how much, or so. Still, I tend to think that philosophical conversation about SciArt and the similarities between art and science is interesting and important. So, I will highly recommend the following references if someone is interested in philosophical topics. They have had a positive impact on me when conducting my research for this thesis (Bullot et al., 2017) (Heylighen & Petrović, 2020) and Giulia Ghisleni et al. (2025).

One interesting topic is what art can give to science and whether art helps science in its practices. Giulia Ghisleni et al. (2025) summarise several attributes, such as creativity, visualisation, helping to understand difficult science and scientific communication. Both Science and Art need, of course, imagination. As a former natural scientist and art student, I can’t agree more with Ghisleni’s and co-workers’ findings.

It is also always good to remember, and as a nice ending to this subchapter, that Science and Art are foundational movements of society. In summary, Professor of Physics Nicola Godinovic (Godinović, 2020) stated nicely.

$$\text{Culture} = \text{Science} + \text{Art}$$

2.3 Scientific Illustrations

Historically, scientific illustrations are one of the main areas of SciArt. Scientific illustration is an artistic practice to document or illustrate scientific results. The Franklin Institute gives a particularly descriptive definition of scientific illustration.

“...a way to communicate complex concepts, details, and subjects in an engaging and easily comprehensible way...” (The Franklin Institute, 2019).

Another illustrative definition can be

“Art in the service of science” (Arthistory project, 2022).

Scientific illustration, as an artistic activity, has played an important part in the scientific world for several hundred years already. Expeditions and different areas of natural sciences like botany, herbology and zoology often rely on illustrations of high quality that are directly proportional to the artistic abilities of illustrators. This standpoint was very important till modern times, when photography and other technologies were applied for documentary work. One good example of using artists for scientific documentation was Napoleon's campaign to Egypt and the Middle East in 1798-1801. Hundreds of artists were recruited, and they produced over 3000 illustrations from archaeology to other sciences; some of those pictures can find from next reference (bibalex.org, 2021). One good example of early SciArt in Finland was Wilhelm von Wright, who made big contributions to scientific illustrations. Most notable is his series about Scandinavian Fishes (Doria.fi, 2010).

In recent times, modern research methods like microscopy, digital cameras and computers with sophisticated programs have taken their place in modern science, but also give a new format for making SciArt. One of my favourite books on the subject is “The Beauty of Chemistry” (Ball et al., 2020). Photographs in that book illustrate the unseen beauty of different chemical and microscopic phenomena that we can't normally see. Another good book with artistic scientific pictures is Jack Challoner's “Seeing Science” (Challoner, 2022).

Science-based photography can be one way to introduce the multitude of aspects of their work. One good example is Nature magazine's annual photography contest about scientists at work (Nature, 2025).

When dealing with the history of SciArt and Scientific illustration, one figure can be introduced. Multitalented Leonardo da Vinci is the most prominent historical figure to combine art and scientific thinking in his personal works. In his famous illustration, he combined a human figure with Platonic geometries called the Vitruvian Man; see Figure 1. That and other very technical drawings about anatomy and technical innovations give him iconic status in the SciArt field, even though in his time, science was not established in the way we know it now.

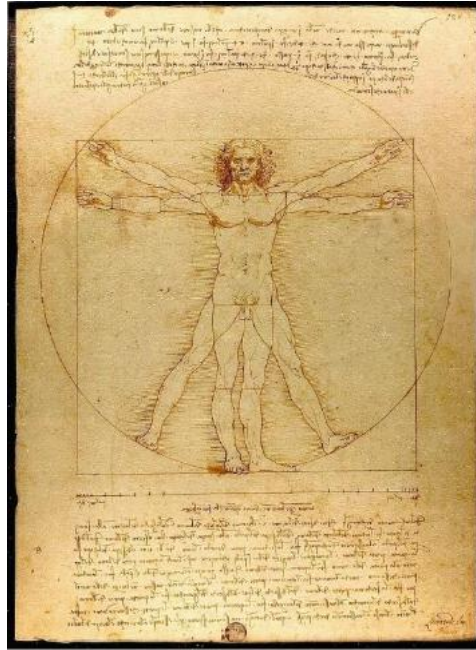


Figure 1. Vitruvian Man by Leonardo da Vinci, c.1490. (Wikipedia, 2026)

2.4 Some internal themes in SciArt

SciArt can have a lot of themes or philosophies within its context. For this thesis, one is to make visible scientific phenomena that are out of the scope of our senses. I believe that can be one of the important functions of SciArt in future, because microscopic-level science is evolving, and cosmological-level findings are easier to understand with visual materials. One book I like to recommend, about making the microscopic scale more visible, is “Seeing Science” (Challoner, 2022). Interestingly, modern science has evolved to a state where scientist and illustrators must sometimes use their imagination and techniques like before the camera was invented. In chapter 4, we discuss that more.

Figure 2 is a demonstration of how to show very important biological or ecological phenomena that are hidden in soil in a very simple manner. It is photographic documentation of environmental art, mixing a SciArt-themed work called “Recycling”. It shows us how

water is recycled in nature. Melted snow turns into water molecules, and under the soil surface, trees will collect water to recover from the harsh winter. A not-so-attractive pile of snow will be left in the end, life-giving to the nearby trees and moss.



Figure 2. Recycling. Environmental art mixing BioArt and SciArt. Photographed and made by the author, 2022.

One interesting science-related art trend or subcategory of SciArt should be mentioned because of its popularity: BioArt. In BioArt, artists work with biological and living materials in very collaborative ways. Materials can be living plants, microorganisms, or genetic material made in a laboratory. In Finland, the BioArt Society is lively and has organised several events, from exhibitions to residencies. For further reading about the art trend in Finland, BioArt Society's website is recommended (Bioart Society, 2026). As an example of bio art, Figure 3 shows an installation with nettle leaves, mimicking the wind movements that leaves experience when they were crowding in the garden a couple of hours earlier. Decent scientific findings show that plants have memory (Atlas Obscura, 2017).



Figure 3. Memory of wind. Installation with nettle leaves. Photographed and made by the author, 2023.

2.5 SciArt today

The authoritative science magazine *Nature* recently organised a poll mainly for scientists about collaboration with artists (Nature, 2021). Results were very illuminating; there seems to be a need for collaboration with artists in the future. Naturally, there is an urgent need in the science community to bring their work to a more easily accessible and more understandable format for people outside science circles. The science community sees SciArt as a very relevant communication tool. Some good positive research results about Camilla Rostvik were studied in his doctoral thesis on artist roles in the science community at CERN very thoroughly (Røstvik, 2016). Alice Fleerackers et al. also conducted a large analysis of artists (a total of 131 artists) in the SciArt field (Fleerackers et al., 2022).

Several other trends show clearly the popularity of SciArt globally. One is residency practice with science organisations. Most notable is, of course, CERN (*Conseil Européen pour la Recherche Nucléaire* ('European Council for Nuclear Research')), which has offered several years of collaborative residencies for artists (CERN, 2026). Also, Art Hub Copenhagen with the Niels Bohr Institution (Art Hub Copenhagen, 2025). As well, several organisations have been formed to promote SciArt, like SciArt Initiative (SciArt Initiative, 2026), Science Art Society (European Commission, 2026) and SciArt Exchange (SciArt Exchange, 2026).

To me, it looks like SciArt is relatively unknown in Finland, at least among artists. It was a little bit surprising, because Finland is well known for a higher standard of science. On the

other hand, it's understandable. But some interest has been shown in the academic world, and a couple of conferences and seminars have been conducted in recent years. One was at the University of Oulu, "Oulu Art and Science seminar" (University of Oulu, 2023).

One new aspect or positive trend we can find is also in the SciArt movement. SciArt is a context that can provide a safe forum for scientists to express their artistic creativity. For instance, a UK-based SciArt organisation's website (SCI-ART, 2026) has a list of professional scientists who are practising art in the SciArt fashion. As a former academic scientist, I see this trend as heart-warming. Who would be better to present scientific information to audiences than professional scientists with good artistic skills and self-confidence to step into public forums with their art? I also see a lot of possibilities that art-based methods can provide new ways to communicate in scientific discussions. One picture can tell more than 1000 words. One of my favourite scientists/SciArt artists is biologist Bryan Welm, who makes interesting sculptures with biomolecular influence (The Scientist, 2026)

2.6 Mathematical sciences and art

Because the science part of this research is based on physical phenomena, it is relevant to talk a little bit more about the connection between physics (and mathematics) and art. Physics and art have a lot of common ground. Both are well known for the use of concepts like time, space and place (Shlain, 2007). Of course, it is easy to say that an artist's apprehension about time or place is different from a scientist's because modern science deals with time or length scales that we can't observe with our own senses. I don't think that way. Modern surveyors observe nature in a quite similar way to landscape painters. The surveyor uses, of course, state-of-the-art equipment, but are they just an extension of human senses? Naturally, art and science eventually go their own directions, but at least at the beginning of the observation process, they surprisingly have the same basics. If the reader is interested in knowing more about the similarities between art and physics, Leonard Shlain's book is a good start (Shlain, 2007). I also tend to think that SciArt can be a vehicle or philosophical ideology to bring them closer. Not to make them united, but a little bit overlapping.

Historically speaking, modern physics started its triumph more than 100 years ago. The leading theories were general relativity and quantum mechanics. Soon after that, many other physics branches started to evolve, like cosmology, statistical thermodynamics, nuclear

physics and others. It is also linked to the evolution of modern measurement technologies at the same time. But same time, new modern art styles emerged that took strong inspiration also from scientific discoveries of that period. Cubism, surrealism, modernism, futurism and abstract art, to name a few styles, have ideological connections to science. In his book “Lumen Naturae”, Mathilde Marcolli (2020) presents numerous examples of how artists have adapted new physical and mathematical concepts to their art in the last hundred years (Marcolli, 2020). As an interesting side note, she also suggested that before A. Einstein introduced the concept of curvature of space, which was used by artists like Cézanne (Marcolli, 2020). Also, it is well known that surrealism takes a lot of influence from quantum mechanics, which was developed in the same era, most notably Salvador Dalí (Parkinson, 2004; Charalampous & Trigoni, 2020).

Mathematics is always linked to art, or at least some mathematical sub-categories like geometry and algebra, to name a few. A couple of decades ago, Chaos Theory was popularised in the media with its very interesting concepts, like the butterfly effect; it started to flourish as its own visual world (Starts with A Bang, 2018). Many artists started incorporating mathematical chaos formulas with graphical design programs. J. Kappraff discusses more details about chaos theory in Art and Nature (Kappraff, 2021).

Perhaps the most famous mathematics-based artist or mathematical artist is the late M.C. Escher (1898-1972). He is well known for his repeated use of small figures in a very clever repeating geometric manner. Also, in some of his works, he bends space, making unrealistic scenery which challenge viewers' logic. I recommend Doris Schattschneider's book “M.C. Escher, Visions and Symmetry” (Schattschneider, 2004). M.C. Escher's art, or the whole mathematical art genre, would be an ideal way to introduce the SciArt world, because it is easy to understand and has a lot of geometric beauty. Other mathematical objects with beautiful geometry are the so-called Penrose tiling (invented by Sir Roger Penrose), which has a certain natural artistic beauty (Wikipedia, 2026). Figure 4 is an example of a Penrose tiling with two fundamental tiles. Mathematical art, or math-based art, is also referred to as Math Art.

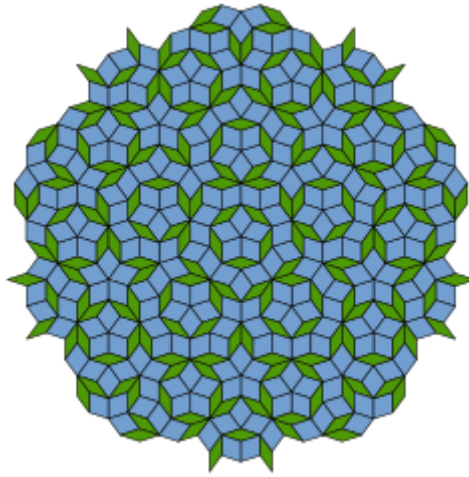


Figure 4. Penrose tiling. (*Wikipedia*, 2026)

2.7 Artist's roles in the SciArt field

Several interesting questions arose when I was writing this thesis. They are different artist roles and possibilities to work and specialise in SciArt or scientific illustration in Finland. First, artists can take many roles. Several studies predict an increasing need for artists in the science field, so artists can specialize to Scientific illustration. Also facilitate SciArt workshops, create social media content or make art or design inspired by science and so on. And that leads, of course, to a question about a valid specialised artist education in the field. In Finland, I didn't find any regular courses for scientific illustration or introducing level course in SciArt when I finalised the writing phase of this thesis. Only one valid online course was available (Leskinen, 2026). Also, one minor study about Math and Art at Aalto University (Aalto Yliopisto, 2026).

To compare, several universities in Europe and America have well-designed curricula for bachelor's and master's degrees (Scidart Academy, 2024). Of course, Finland, which is well known for high-level scientific research, is a relatively small nation compared to other European countries. So, there is probably no need for regular higher-degree-level programs in art schools or universities, but minor programs for those who are interested in working

with scientific illustrations or similar works would be appropriate. That can be open to artists, designers, scientists or technicians as well. Workshop models (with a more intensive schedule and strong emphasis on group work) with science-oriented topics can also be one way to introduce artists to science illustrations. One motivation for this study (that arose during writing this thesis) is to test whether this kind of workshop model as future possibility to introduce Scientific illustration to students.

3. Art-based research and methodology

Research in the art field can take several research approaches and methodologies. Which methods or research strategies to choose depends on various reasons and interests. Variables like the research topic, the way data is collected, analysis techniques, and the purpose of research, just to name a few. In this research, some different art-based research methods or strategies are used, and they are introduced briefly in this chapter. All of them are very commonly used in the art research field, and they can be treated as established methods. So, for that reason and to keep this thesis compact, I decided to discuss only the method aspects that are needed to understand this research. Naturally, many methods have a very vast philosophical background; many textbooks have been written about applications, interpretation of methods and so on.

3.1 Meaning of research

Before going in-depth with research methods and strategies, it is appropriate to discuss what research is. OECD's (Organisation for Economic Co-operation and Development) definition of research activity is that it is a systematic activity to increase knowledge and use knowledge to find new applications (Anttila, 1998).

As P. Anttila also stated, research can divide to three fundamental categories: basic research, applied research and development research.

Basic research can be understood as an activity to get new information as the primary motivation and has no application.

Applied research can have a strong motivation for real applications but can also have a basic research aspect. Also, applied research can find applications for already existing knowledge.

Development research is an activity where already known knowledge is used to make new applications or improve already existing applications. (like products, methods). E.g., action research is categorised as development research. (Anttila, 1998)

Research work can take many forms, interests, and attitudes. It can be small-scale testing to improve something without spreading or publishing findings to outsiders. A good example is companies' R&D projects. On the other side of the spectrum are multinational research organisations like CERN, which is established to find new public scientific information, with several years-long research projects and with thousands of researchers and technical people working in one organisation.

When research work is done with a scientific attitude or tradition, for example, using already established methods, protocols, and equipment, or when reports are written with commonly accepted rules and are peer-reviewed and published, research can be referred to as scientific research. This study aims to find new information or understanding using scientific methods and traditions.

3.2 Art-based research and Action-based Art research

Before we discuss Art-Based Research (ABR) as a method, some historical background would be appropriate to discuss to understand the motivation behind it. In art research (which is a new tradition compared to other traditions like social and psychological fields), a lot of research methodologies and strategies were borrowed from other research fields. Social science and educational fields are good examples, whose research methods are widely used in art education and applied visual arts (Jokela & Huhmarniemi, 2020, s. 9). Arts-based research, as a new term in the research world, was introduced by Prof. Elliot Eisner in 1993 (Barone & Eisner, 2012, p. ix). One motivation for the development of ABR was to find a new method to gather information that is very internal or subjective at a personal level and hard to verbalise. ABR is an amalgamation of different research traditions. P. Leavy stated

(2018) that art-based research roots are in art therapy research, neuroscience, qualitative research and art research.

Art-based research (ABR) can be described as a research method or methodology, where art pieces and/or different art processes themselves are used as data or a data source. Art that can be collected during the research process can practically be any art form, medium, or combination of those. Different visual materials, dance, art forms that use words, performances, films and so on, are typical materials, but also observing the art process itself is a valuable source of information. If it is possible, like during art workshops, researchers can observe and analyse processes, feelings, thoughts and comments, which can give a lot of data and insight for research analysis.

P. Leavy (2015, p. 4) stated in a very illuminating way about ABR's multidimensional characteristics.

“Art-based research practices are a set of methodological tools used by researchers across the disciplines during all phases of social research, including data generation, analysis, interpretation, and representation.”

ABR is not about getting information about the situation or circumstances; it merely gives information about insight into affairs (Barone & Eisner, 2012, p. 3). P. Leavy, who is one of the leading figures in the ABR field, described it as a paradigm. In a wider scope, the ABR tradition can be seen as an umbrella category that has several differently constructed approaches with different research angles and methods. P. Leavy has also listed almost 30 different terms for ABR or related methods (Leavy, 2015, p. 5). Also, ABR can be understood as a continuum between art and science, where practitioners can choose from more art-oriented action or more scientifically oriented approaches (Leavy, 2017, p. 196). ABR can be exploited in other sciences than art research projects, like social science, education research, anthropology, psychology and health science, as in Part VII in reference (Leavy, 2018)

If we compare it to other research, like art history, social science, etc., that has several-hundred-year traditions, it's natural for it to be evolving and finding new research methods. But also, it's important to understand that, as a widely used method, ABR can be interpreted a little bit differently in other fields (Adams & Owens, 2021)

One of the subcategories of ABR is Action-based art research (ABAR). In historical perspectives, it is also a relatively new research methodology or strategy. It has roots in action research, art-based research and artistic research (Jokela & Huhmarniemi, 2020). In ABAR research, participants or art makers are an integral part of the process, and they can contribute to research in several ways. Like giving their opinions, ideas and experiences at every stage of research, during the planning period, execution of art-making, and after the gathering. Different kinds of feedback, queries, and group- or personal-level interviews are applied as a data collection method, but art pieces themselves are also an integral part of data collection. Art can give knowledge that is difficult to verbalise or, in some other way, hard to see. Also, facilitators are an integral part of art-based research, so different kinds of field notes taken during the process are essential research material for the analysis stage. Also, sketches, meeting memos, documentation, and so on are an important part of the data. (Jokela & Huhmarniemi, 2020). Thus, in an ABAR-based research strategy, it is relevant to collect data in various ways to give wide possibilities for the analysis process itself. (Jokela & Huhmarniemi, 2020)

Action-based art research has been studied and developed strongly at the University of Lapland over the last few decades. It has been applied in several communal art and art educational workshops, but ABAR is very applicable to other art-based development projects. Especially, different art workshop developments, design projects and applied art projects can have benefits if ABAR is applied in their development stages. ABAR can be a very useful aid in cyclic development projects like Service design

To me, as a natural scientist, ABR and ABAR look like versatile methods or more like an approach that can be modified very easily to all kinds of situations, and they can easily adapt to collaboration with other methods. In many ways, technology development or applied scientific research has the same kind of attributes as ABR and ABAR.

3.3 Qualitative and quantitative analysis

In the research world, especially in social and educational science research, the traditional way is to categorise research methodologies into two categories: quantitative and qualitative analysis traditions.

Quantitative methods are usually used in conjunction with well-defined theories and mathematical data processing. So, numerical or statistical results are usually associated with quantitative methods. In particular, many natural science research traditions and statistical social science can be understood as belonging to this category. Often, research results are also validated by research done before.

In action-based art research or art-based research, and in this thesis, a qualitative approach is also used. Hence, more subjective answers, like individual opinions and personal feelings, are valuable data.

One aspect of qualitative research is its versatility. Jari Eskola stated, “In qualitative research, in the best case, research plans will transform with the research project” (translated from Finnish) (Eskola, 1998, s. 15). This is one important factor when working with ABAR or a visual project that is dealing with service design or a project with applied arts. Between these two methods is sometimes unnecessary opposition. J. Eskola proposes (1998, s. 14) them as a continuum, where to choose the best-suited methods to conduct research on the task at that moment.

3.4 About Communal Art, researcher's role in research and ethical issues

Although community or communal art is not an aspect of research, it should be discussed briefly because this workshop has a lot of components and aspects of it. Community art is an art-making process where a group of participants collaborate for a common cause, which can be art pieces, other products, etc. Usually, the artist that facilitate that art process is called communally artist, and their role is to facilitate but also create a safe space for participants to experience the collective creation process most positively.

In this workshop, participants work closely and communicate with each other, do small exercises together and build the exhibition with the final opening, which was also a group effort. Students were from the same faculty, so social bonds between them were strong. It is reasonable to predict that these social interlinks have positive effects, and I predict that it has its own effect on the results. In some sense, results can also be seen as a group voice. All participants were adults, art enthusiasts, interested in science, with formal educational was in same level and so on.

When practising, the research role of an investigator is always considered. Depending on the research methods and analysis, and when working with a group of people, a facilitator/researcher has some effect on group dynamics, how people communicate, and so on. Also, how much the facilitator involves himself in art-making, and how much that affects group work and so on. When conducting research and analysing results, the facilitator should consider the ethical aspects of research.

When working with individual persons or groups of people in communal art or collecting research data, several ethical issues should be dealt with utmost care. One is the participants' right to choose anonymity from outsiders and the publicity of their works. The usual practice is that every participant signs a contract before the workshop (Jokela & Huhmarniemi, 2020).

As P. Leavy stated (2017, pp. vi-vii), "...ethics are intertwined with all phases of the research design process." Facilitators and researchers should be very observant during the art-making process with the group and be ready to make changes to research plans if necessary. Timo Jokela and Maria Huhmarniemi (Jokela & Huhmarniemi, 2020) listed several topics that should be dealt with ethically, like research goals, participants and facilitator/research roles, defining research questions, art-making practices and how to present results.

3.5 Research questions and summary of the research strategy

For this thesis, research questions are postulated below with necessary explanations.

1. A. Can the SciArt workshop experience help participants to see similarities between science and art?

1. B. Can the SciArt workshop experience give a new understanding of the similarities between the works of artists and scientists and their inner motivations?
2. Can SciArt workshop experiences lead to a better understanding of physical phenomena that are too small to be observed by our senses and research equipment?
3. Can SciArt workshops be a relevant method to learn/teach aspects of Scientific Illustrations?

Firstly, let's open the first research question. The history of science and art is long, and throughout history, philosophical questions about their similarities and philosophical natures have been a very interesting topic in academic work, but also for laymen. I, as a natural scientist and art student, have found these similarities very easily with pragmatic thinking and at a very subjective level. So, it is interesting to see if participants who make SciArt can experience these similarities.

In Chapter 4. The workshop will be presented in a more detailed way of what it means if some physical phenomena are outside of our seeing abilities or out of the measurement devices' capabilities. Interesting questions arise from this direct visualisation border. How the smallest object look like, and how to visualise those particles? Other questions also arise: will we start to learn or understand those small-scale phenomena when we make art from them? As a natural scientist, I know (based on my own experience) that making drawings and pictures can help to understand abstract concepts.

To my knowledge, in my home faculty at the University of Lapland, a SciArt-based workshop has not been conducted for a while (or perhaps not before). It gives a new opportunity to test a new workshop concept for future use at the university level. One important aspect of SciArt is scientific illustration, which can be a realistic working area for some students in the near future, due to the increasing need for quality artistic illustrations (The Franklin Institution, 2019). So, it was natural to investigate whether this workshop model applies to scientific illustration education in future. In some sense, persons who attended this workshop can be treated as models or standard persons for workshop development in other faculties and institutions.

Also, with the aid of this workshop, can SciArt be promoted as a new inspirational art trend for artists, or also for someone that want to profile as a communal artist and offer workshops with science as a theme.

In this thesis, although they were not original research questions, I will introduce other findings and ideas that arose during the analysis of the state and conversations with

participants or exhibition visitors during the process. They can be treated as a validation of the original research questions or as useful information for future research and development.

In this thesis, the research strategy and methods can be categorised as a mix of art-based research ABR and action-based art research ABAR with a qualitative approach. Research in this thesis is, more or less, applied research and first-stage development research.

In this thesis, the major data collection sources were feedback queries, artworks done in workshop gatherings and exhibition artworks. During this workshop, private and group conversations were also valuable information sources, as well as communications with the audience at the exhibition. Small art-based exercises were done during workshop gatherings, and artistically more challenging works were done during a period of a couple of months before the exhibition. Feedback was collected after workshop meetings using forms with several pre-designed questions. Questions were designed to provide information for research questions, but also to provide a wide range of information about participants' experiences before the workshop and during the workshop, as well as some information dealing with their artwork process for exhibitions.

The artworks presented in this thesis are treated and presented anonymously, and the results collected from feedback are presented as a coherent conclusion with quotations from participants' feedback. I also choose not to shown pictures with participants' faces. Numerical values are not presented in this research due to the nature of feedback queries and because there are no theories or other similar studies to verify with numerical values. Although it might be possible to get numerical values with a decent margin of error, I feel that it would not give any valuable information or insight into the results. I believe that every participant's answers were already thoroughly reflected by themselves, so they should be treated as they are. The aim for the number of participants was a maximum of 10 people, so there was no need to restrict the time spent on analysis of feedback. In the end, it was possible to make a coherent conclusion from the collected data.

3.6 Critical insight into the literature

In this thesis, the theme is SciArt. It is a relatively new art trend as a research area, and that can also affect the narrowness of the research literature that is available, at least for my research. I was interested in whether the SciArt workshop experience can give insight into similarities between Art and Science, and whether participants can find common factors that scientists and artists share. To my knowledge, there were not so many studies with an experimental attitude in mind. On a philosophical and theoretical level, the material is numerous, as one might expect. For validation of research results, I found some research articles and books, luckily. As a summary, to me it looks like modern SciArt research is more interested in it as a social phenomenon, the art history or philosophy side of it. Next I list of papers that were useful for this research and were not reviewed before in this thesis.

Recently, several extensive studies have been conducted about the artist's role and collaboration with science world, and the results were very illuminating. Firstly, the level of collaboration between research organisations and artists was surprisingly lively. This collaboration is seen as beneficial to both parties and learning from others' crafts. Graves et al (2025) studied a lot of artists' roles and experiences when they work closely with science communities. Their findings show mutual benefits for both professions. They found that artists feel they understand science more after working with science. Camilla Rostvik (2016) studied artists' roles in CERN and the need for scientific communication. Alice Fleerackers et al. (2022) studied artists' perspectives after working in the SciArt field by interviewing 131 artists. Maria Huhmarniemi (2011) also writes about the multitude of aspects of artists' roles. Nature magazine organised a Gallup poll about the future need for SciArt-oriented artists, and the result was very positive (Nature, 2021).

Luckily, I found at least two sources that reports own personal experiences about similarities. Artist Laura Pesce (who has specialised in incorporating physics concepts in his artwork, and her husband is a physicist!!) has written a book about the connection between physics and art (Pesce, 2019). She finds, through her artmaking period, similarities between art and science. Another one was an article that was written by Nobelist neuroscientist Robert Guillemin (Guillemin, 2010). As an artist with his own exhibitions, he finds a lot of common factors between science and art, like intuition, problem-solving, and the way of observing our world.

One area of SciArt should be mentioned due to its importance, and perhaps the results of these studies can be used in this context. In educational research areas, art-based methods are well studied in improving student learning experience. Well-established STEAM pedagogy is often used in natural science and mathematical education (SciArt Project Consortium, 2024). STEAM (Science, Technology, Engineering, Art, Mathematics) is widely used in Finland in LUMA centres located in several Universities.

4. Workshop

This chapter presents key points from the planning stage to the actual workshop and final art exhibition. The emphasis is on presenting the workflow that leads to the workshop, but also on providing background for the choices made during the planning stage and the workshop. Also, selected pictures from workshop exercises and art exhibitions are presented, as well as some of my own findings and observations during the process.

This chapter also has a shortened summary of the scientific content used in workshop lectures. They were themes and inspirational material for artworks and exercises throughout the whole workshop process. One motivation for giving a summary about physical concepts is that the reader can better understand the art presented in this thesis and the inspiration behind it. Also, to clarify the concepts behind the idea “... make unseen seen.”

In this summary, we don't use mathematical formulas, other complex scientific materials or graphs. We concentrate more on verbally simplifying models that can be understood easily at a conceptual level without special studies in the field of mathematical expertise. That was also my guideline for workshop lectures.

4.1 Planning stage for workshop

Before arranging an art or communal artwork workshop, a couple of questions are usually considered. One is who the target persons or groups are. Typically, participants' social and educational background is necessary to understand, but attributes like age, history or personal abilities are usually considered in the planning stages. In this work, the target group was university students, who most probably also have a high school level education with

some degree of experience with mathematics and natural sciences. That gives confidence to choose ideas and themes also from mathematically oriented science and more challenging physical topics.

When planning artwork workshops, another factor to consider is critical. What is the participant's experience with art making, different materials and mediums? This workshop's target group was fellow art students, who, practically speaking, are already professional artists with trained skills to produce art at a fast pace. This gives a lot of freedom in the planning stage, and it was very clear that every artist can choose their materials and do what they want with their ideas. Also, they don't need to be guided in the use of materials.

My own background in natural science was also a leading factor in choosing science-based workshops. Of course, confidence to give lectures on physics topics, but also my own interest in the SciArt movement and philosophy of art and science. Also, frankly, one strong motivation was to offer new themes and experiences for people to attend this workshop. To my knowledge, this kind of workshop has not been offered before in my faculty.

4.2 Choosing criteria for topics and what the chosen topics can offer to artists

First, before choosing topics for lectures, I had a small Gallup poll among my fellow art students, whom has an interest in SciArt-based workshops. I have several candidates for topics to choose from. One was General relativity and inflation models (aka Big Bang Theories), which are well known for their curved space models and interesting concepts about the universe and time. I was thinking that they could offer very visual material for the artworks. Another area was Particle physics and String theories. They offer different time and length scales from our normal life, and they have a lot of quantum mechanical effects that can be fun to visualise.

Secondly, it should be something that everybody knows at least a little. For example, in recent years, many have read or heard news about new results and progress, the most famous being the Higgs Boson from 2012 (Yle, 2012). Many university students, who were the target group for this workshop, have a high school background and so have some basic understanding of science.

Thirdly, it is also important to offer different angles or points of view to approach these topics to give more possibilities to choose artists' directions. In particle physics and other subatomic worlds are things that we can't see, and there is no apparatus to zoom in on those worlds. We don't know what subatomic objects look like. The knowledge of those objects comes from theories, model simulations and indirect measurement results. That can give a lot of possibilities and free space for artists to use their imagination and visualisation skills. An Artist's intuition is as good as a scientific person's, and of course, an artist can see things a little bit differently.

Also, even though many modern theories are widely accepted in scientific communities, they have their own faults and shortcomings. Naturally, within scientific communities, there are always debates and critical conversations about the realism of theories, the reasonable outcomes that follow from them, and the lack of experimental evidence to validate them. A good example is that we can't prove string theories by measurements; the required scale for accelerator experiments is that of our solar system. String theory is famous for its need for extra dimensions, aka 10 or 11 dimensions. It is criticised by some scientists that those extra dimensions are only needed for mathematics, and so they are not a good theory at all. This understanding of the nature of cutting-edge science can also give new angles to artists to create art from subatomic science. Artists can take a very critical attitude towards theories in art-making, but when artists realise that nothing is sure or proven, and the evidence is not certain, artists can also take philosophical or even religious angles in the art-making process.

One important factor was also to offer participants scientific information or topics which can be very visual, and the subatomic world has a lot of very surprising phenomena that challenge our usual way of thinking about our environment or nature. So, topics were chosen to be the Strong force and String theory. The strong force has phenomena that challenge our normal way of thinking a little bit, and its coding has taken inspiration from our macro-level colour theories. String theory is the theory of particles' inner structure and has also phenomena that are a little bit unfamiliar to those outside of the scientific community.

The level of science in the lecture parts was chosen so that everybody could understand it. Emphasis was on clear and simple illustration of concepts and main phenomena. Formulas and other advanced scientific tools were intentionally left out of these workshop materials. The emphasis was on participants understanding basic concepts and phenomena at the conceptual level. Lecture material in the workshop was made at the same level of expertise as the most common information sources. Like some common articles found on the internet, such as Wikipedia and other scientific sites. The same information can also be found on

YouTube. The idea is that after lectures, participants can find further information for their artwork process or can continue their studies after the workshop period. One idea was that if participants want to conduct their own Sci Art workshops or science-based art activities, they can collect information from commonly available sources.

4.3 Physics part

4.3.1 Scaling down to nuclear scales

In this subchapter, I present some concepts that were introduced in the workshop. These lecture topics are summarised here so that the reader of this thesis can understand some ideas behind the themes and some fundamental knowledge, so that the artworks presented in this report can be understood more easily.

One of the important factors when someone is introduced to nuclear and smaller dimensions is to understand the length scales of different objects. It gives a very easy idea of how small things are, but also how small objects modern science can deal with. For this theme, we introduce scaling down in length with the next table, from the bigger microscopic objects to the smallest objects that science has theoretically observed. The first part of the workshop lectures was also about this topic.

Table 1. Table about the physical levels.

Physical level	Length of objects in centimetres
Molecular level	$*10^{-7}$
Atomic level (the smallest level we can see)	$*10^{-8}$
Nuclear level	$*10^{-12}$
Particle level	$*10^{-16}$
String theory level	$*10^{-32}$

The most important aspect of this table is to understand that modern measurement methods give some level of visual (aka. dimensional) information only from molecular and

atomic levels. For smaller dimensions, science uses indirect methods. Art that was made in this workshop deals with phenomena at the level below this length. In this work, we don't deal very much with this scaling-down process, but I highly recommend modern introduction-level textbooks, like H.C. Ohanian's "Physics" (Ohanian, 1989) or K. Krane's "Introduction to Nuclear Physics" (Krane, 1991) or even Wikipedia, for further reading.

4.3.2 Strong Force and Quarks

The strong force is one of the four governing forces of our physical universe, according to modern science. The magnitude of the strong force is higher than the other 3 basic forces that are also in Table 2.

Table 2. The main forces of the universe.

Name of the force	Interaction range in cm	Relative strength to the strong force
Strong force	10^{-13}	1
Electromagnetic force	infinite	1/137
Weak force	10^{-16}	10^{-6}
Gravitation force	infinite	10^{-39}

As we can see, the strong force is the most dominant at the subatomic level, and it maintains attractive forces between/inside material particles like protons and neutrons. Without a strong force, our physical realm wouldn't be possible, at least the way we know it. So far, quarks are the smallest material particles that modern science has proved to exist by experiments. Both the proton and neutron consist of three quarks, with different combinations of quarks named up (u) and down (d). Quark structures in the proton and neutron are illustrated in Figure 5.

The strong force is the so-called "three-polar force". Compared with other forces, which are usually two-polar forces, like electricity, which has two polar centres, plus (+) and minus (-). An analogy to understand this force is taken from colour theories, where the three basic colours are red, blue and green. When these three colours are mixed, they produce white.

One strong force polar centre takes one colour of those three, and an outside observer can see a particle, like a neutron or proton, as neutral, and the strong force doesn't act outside of the particle's surface.

In modern physics, every force is carried by so-called exchange or carrier particles. In the case of the strong force, that particle is called a gluon (glue particle). In the next picture, from the mass particle's inner structure, gluons are illustrated as a white spring. The strong force was one of the chosen topics in workshop exercises.

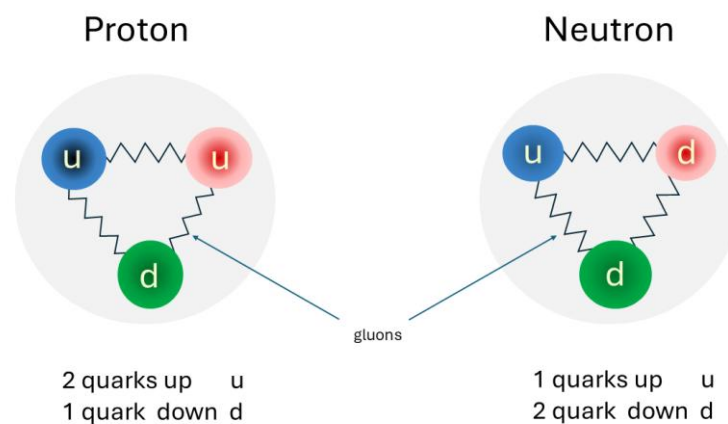


Figure 5. Schematic pictures of protons, neutrons, and quarks. Design by the author, 2025.

4.3.3 String theory

String theory is a theory about the smallest material particles in our universe. In the last sub-chapter, we introduced quarks as proven particles by science, but their finer inner structure is still under research. String theory is the most popular theory for that.

In String theory, the smallest particles of the physical world are constructed by very small 1 and 2-dimensional strings, which have different vibrational frequencies. In every material particle, physical aspects are thought to be manifestations of those small vibrations. Thus, properties of quarks like electric charge, colour of the strong force and mass can be represented by different vibrational modes. These microscopic structures can be strings with

two ends, or they form loops. Quarks that are permanent opponents are understood as a loop-like structure, and short-lived gluons (also other force carrier particles) as short springs.

These vibrational string aspects are mathematically complex. As string theories and computer technology have evolved, very complicated structures can be presented. In the next picture are two modern visualisations of what strings might look like.

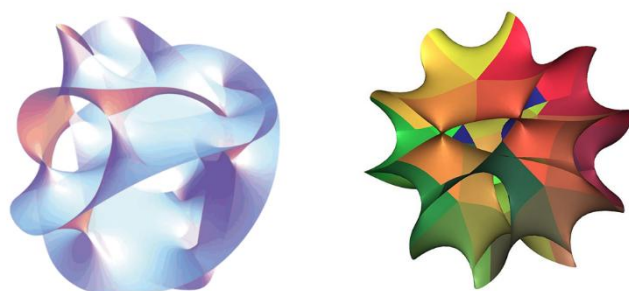


Figure 6. Two ensembles of strings. (*Wikipedia*, 2026) (*Wikipedia*, *Calabi-Yau_manifold*, 2018)

4.4 Common theme for workshop

When the Gallup stage was finished, and topics for the lecture and workshop artworks were selected, I started to think about a common theme or idea for the workshop. The chosen physical phenomena were all on small length scales that we can't see. So, one of the core themes for this workshop and for the thesis is how to make invisible things visible to us and others. I must admit, it's not a new concept at all. For decades, SciArt artists have worked with this motivation, and there are several picture-oriented books about it, like the already recommended "Seeing Science" (Challoner, 2022). But to me, and to participants in my workshop, it was a new idea to play with.

So, the title for this thesis is "...make unseen seen". What does "unseen" in this context mean? Something that is not seen or its hide for us (<https://dictionary.cambridge.org/>, 2026). We know there are small particles with curious phenomena, but we cannot see them directly. Thus, they are unseen.

4.5 Workshop

Before the workshop, participants were given a voluntary task. It was watching a documentary called “Sense of Beauty” (Amka Films, 2017; IMDb, 2017). This documentary is about people who are working in the subatomic research field and their relationship to their research topics. In this documentary, several senior scientists talk about their own feelings and how they see their research topics on a very personal level. Also, how their sense of beauty that is behind the theory or scientific results. I was thinking that it gives some kind of idea about the beauty of science (that I have also always sensed), but also helps with orientation to the workshop.

The workshop was at the beginning of December 2022. The first gathering was on 31.11.2022 with an introduction and lecture. Follow-up meetings were on 1.12, 7.12 and 12.12.2022. All meetings were in the Faculty of Art at the University of Lapland, in Rovaniemi. The topic for the second lecture (for the third meeting) was String theory, and it was collectively chosen. Another candidate that I offered was cosmic radiation. Once again, my own predictions were wrong (like in the Gallup phase). And that was a good thing to happen. Even though string theory is a very controversial theory, it is very challenging with its dimensional qualities and qualities, and so it can activate artistic imagination for participants. It is the leading theory in the sub-particle physics field. It has a lot of shortcomings, and it has been criticised a lot by the scientific community, such as (The Guardian, 2006) and more recently (Fridman, 2021). This can also be interesting for participants to understand the difficulties in “cutting-edge science” and adopt a very philosophical or critical attitude in their artistic process.

4.6 Overlook the small workshop exercises and post-workshop feedback

On the second workshop day, the task was to make an artwork about the strong force. The strong force has many attributes, and the loose guidance was that participants concentrate on one attribute and try to make an artwork or drawing illustration. Trying to make the chosen attribute very clear and descriptive to other people, like scientific illustrations in

science magazines or other media. As a side note, when I saw the first pictures, I finally realised that the workshop went well.

The third time, the theme was a lecture on string theory, and participants had total freedom to create art and run experiments. Most of the participants made 3-dimensional presentations about string particles or a brane with different materials. The last part was to disclose workshops and discussions about feelings so far. The protocol for the exhibition was also agreed upon, and oral guidelines for forthcoming feedback and final artworks were discussed.

After the workshop, participants gave written feedback before the group began the artwork period for later exhibition. In this research project, questions were designed to give participants a lot of freedom to express their feelings and opinions. Questions were roughly categorised to gather feelings about the workshop itself, relations between art and science and the work process for exhibition works.

4.7 Exhibition

The exhibition took place from 21.3.- 5.4.2023 in Galleria Kellari in the Faculty of Art. Six participants from the workshop presented their art. Most of the works were designed during the workshop period. Some new pictures were also made for the exhibition. Materials and media were chosen by the artists themselves, and they had their own interpretations of the themes they chose. Only the themes of the works were related to the subject of the workshop. Ten art pieces and one collection of small artworks from workshops were presented. The exhibition name was chosen from several proposals by members of the workshops, and it related to the theme of the workshop. So, as a group discussion exhibitions name was chosen to be

[in]visible.

As it was mentioned before, every participant has a different background and so personal preferences for media and their own style. That can be seen clearly from the exhibition's artworks. An industrial designer interpreted strong force as a light furniture concept, and

handcrafted-oriented participants applied clever 3-dimensional structures in their works, and art-based artists made fine art paintings and pictures.



Figure 7. Overview of Galleria Kellari during the SciArt exhibition. Photograph by the author,2023.

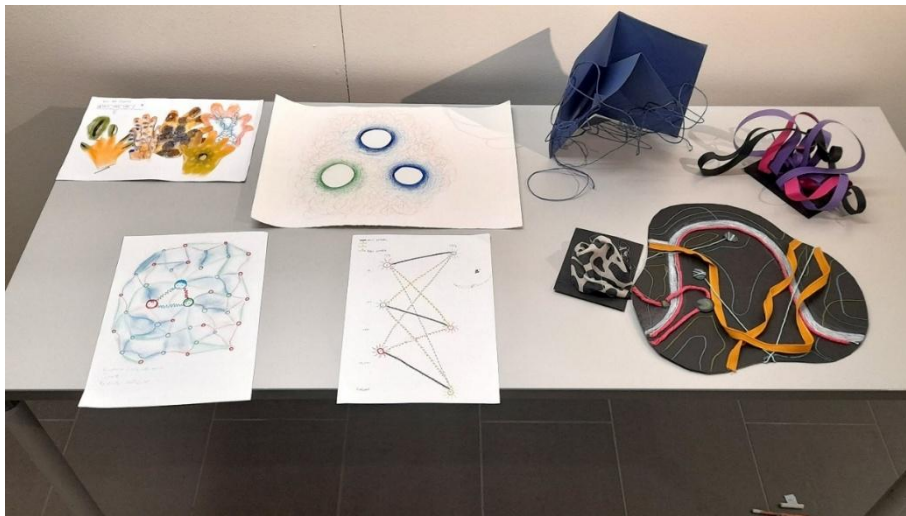


Figure 8. Collection of small works made during the SciArt workshops. Photograph by the author,2023.

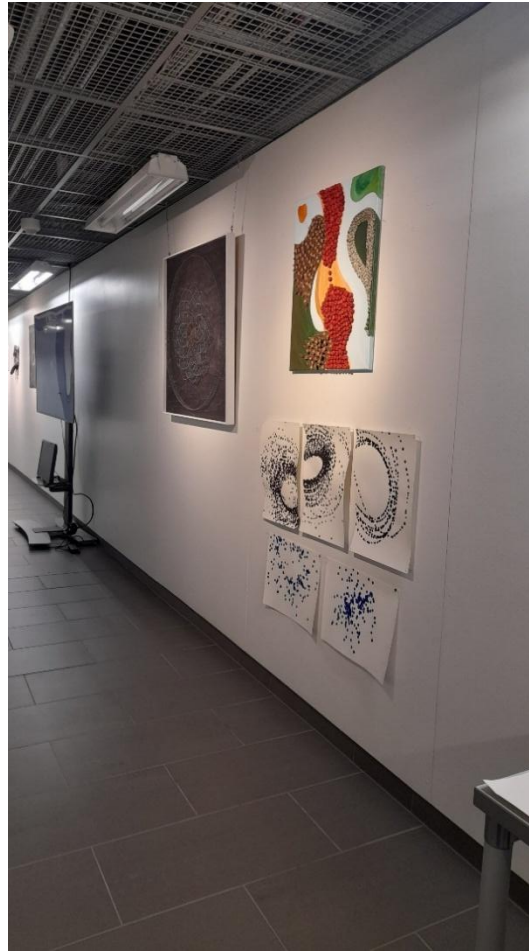


Figure 9. Another overview of Galleria Kellari during the SciArt exhibition.
Photograph by the author, 2023.

4.8 Own impressions of the whole process

Overall, the workshop course went without major problems. All participants liked the scientific topics, and I found that after lectures and meetings, conversations about SciArt or science continued. Although results and findings are properly discussed in the next chapters, some observations are good to point out in this chapter also, because they are close to workshop planning and execution of the workshop. Firstly, not much material was given beforehand to participants. That was the intent, so participants could come to the workshop without preparation and with an open mind. Next time, I would consider providing some materials to participants before the seminar or lectures. Of course, it's also up to the nature of the topics and the people who attend the workshop. Participants can benefit from preliminary materials if the subject needs time to understand.

It was also good that participants could affect science topics. Of course, as a facilitator, one must be at one's own comfort level with topics, but in my case, these workshop themes were familiar, and I presented them to choose from. Originally, the exhibition was not planned for this workshop, but in our faculty, some open positions in galleries were available at that time. It was also the participants' decision to have that exhibition when I asked their willingness to have one. It gave a very formal and jubilant ending for all workshop attendees. I also saw that artists were very proud of their art in the exhibition.

To me, as a facilitator (and as a scientist and artist), this workshop was a valuable experience in many ways. This was the first official art workshop and experience, from planning to exhibition, which gave insight into how to do things and what can be done differently.

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5. Results

In this chapter, we go more deeply into the results gathered from the workshop feedback, analysis of the workshop process and artworks done during the workshop and at the exhibition. In addition, we also discuss and analyse a little bit of work done with physics in mind. Although it is not a research topic, it can also offer an interesting view for analysis. In this analysis, I must rely on my former schooling in university-level physics, as well as my experience as a researcher and in science-related work. The idea behind this kind of analysis is not to test or prove that workshop participants understood physics concepts, but rather to uncover interesting interpretations and offer something new, especially to the scientific community.

Also, I will present some of my own findings and suggestions from the analysis period. Naturally, they are not answers to research questions, but I feel they are important to document because they can be useful to people planning to facilitate a similar workshop or other science-based art activity.

5.1 Overall Analysis of Workshop Topics, aka Physical themes

Before going more deeply into the analysis of feedback and artistic work done in the workshop, I would document some findings or thoughts during the workshop process that deal with lectures or physical themes, aka the science part (Physics), which was frankly the most important part in this workshop.

Firstly, the subject of scientific topics in the workshop was very challenging. So, naturally, there were also uncertain factors, such as how well participants retained information and how that affects their feelings and their motivation to continue in the workshop. These topics are on different time and length scales than those we normally deal with in everyday life, and some physical concepts can take time to grasp at the conceptual level.

Based on collected written feedback and personal conversations with participants, most participants found the subjects easy to grasp and understand. Some participants reported minor difficulties at first, but in the end, everyone managed to complete small exercises

during the workshop and create excellent art using “*SciArt wipe*” for the final exhibition. We must remember that participants most probably had some background in natural science in their high school years. Naturally, that can affect the understanding of topics in the fast phase positively. I also think that most participants have a strong interest in this workshop; most were drawn to it because of the topics.

Surely, everybody understands that science will evolve in the future, and theoretical predictions can be proved to be wrong in the coming years. I also get this impression that when physical subjects are a little bit hazy to researchers, and there is uncertainty in topics (also to scientists), it might also ignite artists to be bold with art and be a little bit philosophical too. I also like to promote the idea to the art world that an Artist’s vision can be as good as a scientist’s vision.

After all, we must also remember that participants in this workshop were art students who had diligently trained to create art from different topics on a very short timeline. In this view of an angel, I think that other professional artists can have a very low threshold to do art in the same way, from similar topics. I also think, based on my experience and research findings, that this can be treated as a good sign for further promotion of SciArt to the art community and to artists.

5.2 Results from the feedback

Feedback was collected after workshop gatherings. In this chapter, quotations were collected from feedback and are treated with anonymity in mind. Also, they are written down the way they were given in feedback, without checking their grammar. The first series of questions was designed to give insight into participants’ feelings and experiences about SciArt and the relationship between art and science. The second series of questions was about the workshop, and the third was about the progress of the final exhibition works. Feedback was collected about two weeks after the last workshop day, so that participants’ feelings and findings could be processed further after the meetings.

5.2.1 Summary for workshop

First, we discussed findings about the workshop at a general level. For most of the participants, this was their first experience with SciArt or a science-based art workshop. Some were already familiar with the concept of mixing art and science, but for most of partaker it was their first experience. I would like to quote three participants' answers,

“This workshop was a great opening for the SciArt world and further discoveries.”

“At least I have in my mind a much more clear view about SciArt is “

“I maintain my belief that SciArt serves two fundamental purpose: communicating the results of research to public and inspiring art via science.”

Some of my own memories and notes from the workshop are appropriate to document in this chapter. Sayings like “...something different to normal curriculum...” or “...always liked to try...” were given during conversations. One feedback comment was

“I am super happy that here is a SCIart workshop in this faculty”

I think that participants get a very clear view of what SciArt is and its purpose only after a couple of meetings and group work, which indicates that SciArt is very easy to approach, understand, and experience. I’m very happy with the outcome, the positive feedback, and the fact that I could offer something different to fellow art students.

I also find that group spirit was good during the whole workshop process, which can positively affect positively to success of workshops. I also remember several group conversations with participants after the workshop, and in those conversations, the topics usually centred on SciArt and science. I consider that a good indicator, because the SciArt workshop gives them some new confidence to follow science, and some of them have taken the SciArt influence to their art-making. At least two participants have an interest to continue SciArt adventure. Two participants stated this independently.

“This workshop helped me to kick start exploring SciArt in future.”

“I gained more interest and enthusiasm in making SciArt”.

As in the Introduction chapter, we discussed that, in Finland, science-based art is a relatively uncommon art trend, so we can conclude that the SciArt workshop, as a promotional tool for SciArt (also for art making and to follow science), seems to work fine. Many were pleased about the possibilities to make art for exhibition, and that was also a positive motivation for artmaking. Based on the visitors' comments and my rethinking about the role of exhibitions, I tend to think that they are the best changes to promote SciArt and science to the public. Many exhibition visitors, who were also our faculty art students, reported that they didn't know anything about SciArt before the exhibition. That is also one motivation to promote more SciArt to the artists' society.

5.2.2 Summary for relations between art and science and artists and scientists

For more philosophical questions concerning the similarities between science and the arts, feedback was also very positive, and participants found common themes. To questions like *“...do you think art and science are more related to each other than you might think before the workshop”* and *“Do they have some common factors?”* answers were very optimistic and wordy. Many participants experienced that artists and scientists use both art and science as a tool to understand our world. The next three answers were collected from feedback.

“Art and Science are both human attempts to comprehend and then explain the world around us”

“I think art and science very much related to each other. Both build on humans' understanding, imagination and creativity.”

“I believe that art and science have both similar natures in terms of trying to understand.”

I think these answers are in line with many similar statements that can be found in SciArt-based literature. One example is that Clark et al (Clark, et al., 2020) wrote: *“At their core,*

both science and art are inspired by our basic observations of the world around us “. Also, R. Guillemin (2010) found, through his own experience as a Nobel scientist and an artist, many similar common factors in the same way that participants did. In Chapter 2.2, there are several quotations that are similar in their core to participants answers, like from L.Shlain (2007) and F.Heylighen (2020) statements. I am personally happy that artists find these similarities, because it is my own experience also.

I would like to refer to two very illuminating thoughts about the similarities between the natures of science and art.

“...especially very theoretical and far-advanced physics, and other sciences that study themes that are out of everyday reality and are outside of the perceptual world, are to me very close or even overlap with art.”

“Sciences and arts project and productions can look different on the surface, but when looking in depth, they start to resemble each other surprisingly much”

So, many participants tend to think that both art and science are ways to understand our world. Also, it was clear that participants easily found commonalities between the two. Artists find very subtle tendencies or attributes that are not easy to find at first glance. Even that some instances of very theoretical formations start to resemble art. I tend to think that art can help us understand science, and vice versa, and I believe that if someone would like to explore similarities in a way similar to the workshop participants, they are easy to see. Because these experiences are also very personal, they might differ from person to person, and it will be an interesting topic to research further. What kind of similarities participants will find?

Also, similarities between scientists' or artists' work were covered in a couple of answers. Scientists and artists have the same kind of need to understand the world. Also, curiosity and questioning were attributes of both professions. Two participants concluded that,

“I see scientists and artists have the same point to drive them, that is human need to understand”

“Artists and scientists both approach problems with imagination, curiosity, questioning

and interest in exploration for in-depth knowledge.”

One comment points out an interesting philosophical point of view. It's about how both professions bring some understanding to help us understand our world more positively.

“Artists and scientists alike are equally motivated by this need to understand and bring some order to the chaos of the world”

One research question is whether it is possible that artists can help the science-making process. The next four comments are answers to that.

“I believe some answers that scientists cannot give, perhaps artists can because artists have more free hand in expressing themselves”

“If artists can provide such imaginative solutions to unknown phenomena, perhaps science can use that as their encouragement to explore in that area.”

“...art practice can always be very useful to visualise scientific information.”

“Perhaps artists can help envision objects that can't be seen”

Definitely, the participant has a very positive attitude that art and artists can contribute to scientific work processes. These answers are in line with Graves (2025) and Ghisleni et al (2025) on what art can offer to science. And that is not just that artists make suggestions or help to discover new science. I think that art-based working methods can help to open new ways of thinking and create a new kind of atmosphere that can make a change in working culture, bringing playfulness and so on. Different kinds of art-based methods, like visualisations, group work, and workshops, can ignite new ways of thinking and be a valuable tool for creating a more creative working atmosphere.

5.2.3 Summary for Can SciArt help to understand science

Also, one research question was whether the SciArt experience gives a new understanding of the physical topics at hand. The result was positive, and many reported that they understood physical concepts and phenomena. Three participants' answers were

“... I think there is some new understanding of science and what the things that scientists are trying to find and explore...”

“I got a better understanding (basic) of nuclear physics, the strong force and basic understanding of quarks and their nature”

“This course makes me interested in very small building blocks of the universe.”

Some participants even find that making art with science can be more fun and can be easier than old conventional methods.

“After the workshop, I think that understanding science through artistic methods is more fun and approachable for me and very interesting.”

“To get introduced to physics through art feels much easier compared to studying only theories”

Based mostly on feedback and some conversations in the workshop, I found out that experiencing science and art can give new understanding or insights into science and science-making. That is in line with findings in Graves et al (2025) research, where artists who work longer periods with research groups find they understand science better. Artist Laura Pesce (2019) also writes that making art with physics can give more understanding of topics. Also, Ian Andrews, with his coworker (Andrews & Nikolopoulos, 2018), conducted a quite similar art workshop about nuclear physics with students. His findings were also positive in the same way.

I would like to conclude that making art from scientific topics that have more challenging concepts and phenomena can help to understand topics without complicated formulas and

such. An interesting question arises after analysis: if, after art-making, participants are introduced to formulas, would the mathematical part of physics be easier to understand than in a regular physics class?

5.2.4 What SciArt can teach about science

It's not always about results or understanding the scientific worldview; it's also about the philosophy of science, the mindset of doing science and curiosity as fuel in science-making. SciArt workshops (or SciArt courses) can be a good platform for understanding the world of science more broadly. One theme that was discussed frequently during the workshop period was the interlinking between art and science. Naturally, we can always think that it can be biased to think in a certain way about a subject, but I believe that it gives participants a chance to observe their own thoughts and feelings during the art-making process.

One factor rise during analysing stage was the role of the document "Sense of Beauty" (2017), and at least one partaker mentioning it in their feedback in a positive way. Also, during the workshop, this document was the topic of discussion. That document was about how scientists find beauty in their research field. I have a strong impression that the document might help us understand that a physicist has the same sense of beauty that artists have.

So often I have found that the common belief about science, which is based strongly on mathematical principles, is considered very harsh, pragmatic and without emotions, like compassion, artistic feelings or a lack of connection to daily life. As a physicist, I like the idea that this kind miss beliefs will be corrected, and based on my experience, SciArt workshops can be a good way to introduce the other dimensions of science to the public, for example, positive feelings and the promotion of the beauty of nature, which are common trends among all people, regardless of profession.

Overall feedback for the SciArt workshop was positive and encouraging; it seems, based on feedback, that topics that go to sub-particle levels were fascinating to the target group. I admit that before the workshop, I had some doubts about the topics for lectures, whether they were too abstract or theoretical.

Also, a deeper understanding of SciArt as an art trend arose, based on a couple of feedback answers and a couple of talks. Also, I found out from the exhibition that SciArt is a good concept to promote science to the public.

5.3. Analysis of Workshop Artworks

5.3.1 Small artworks

Strong force

The first artwork in this workshop was to illustrate some concepts from the strong force that are discussed in detail in Chapter 4. The day after the first meeting was conducted, participants gathered in a small lecture room to do artwork. In this exercise, every participant chose one aspect or theme from the strong force phenomenon (based on the last meeting day's lecture) and made one illustration from it. Time was fixed at 3-4 hours. The idea was to concentrate on this chosen aspect and design a picture or art piece to illustrate that concept to outsiders, such as a science illustration. Scientific realism was not an important factor (due to the short timescale and not taking the exercise too seriously), but rather how to present clearly chosen ideas. In the Figure, we see three very different interpretations of three-quark models. Both have the same three-quark structures that the proton and neutron

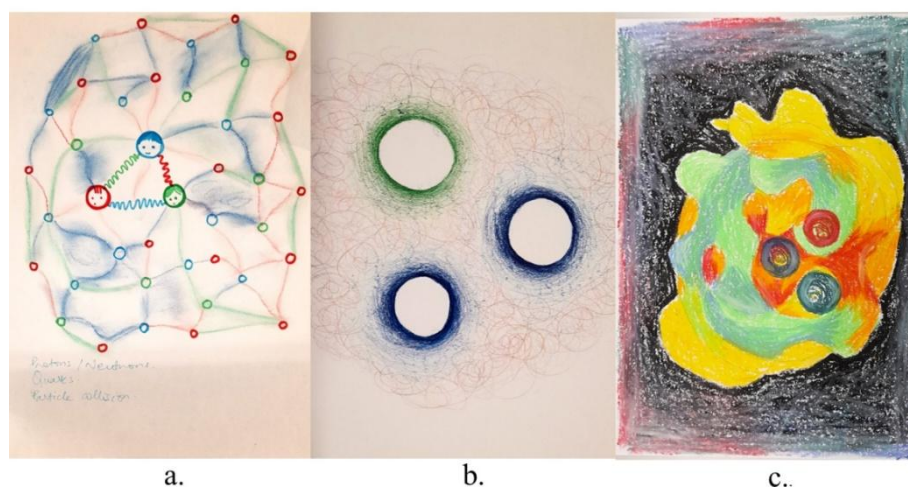


Figure 10 Three artwork about the strong force. Photograph by author,2023.

have; clearly, there are a lot of similarities with Figure 5 in Chapter 5. Workshop. Usually, a proton is visualised as a spherical material particle, but its structure is predicted to be very complex (Max-Plank-Gessellshaft, 2026). Artists have explored new ways to illustrate the spatial structure inside a proton. This strong force field is naturally invisible, but in these three illustrations, it has interesting suggestions about different dynamics of the strong force. Such as the movements of quarks, the spatial strength of the force field, etc. Also, artists take a lot of freedom to follow their visions, compared to a more conventional view, like in

Figure 5. Two other works are displayed in Figure 11. One small work, Figure 11 b, is a collage.

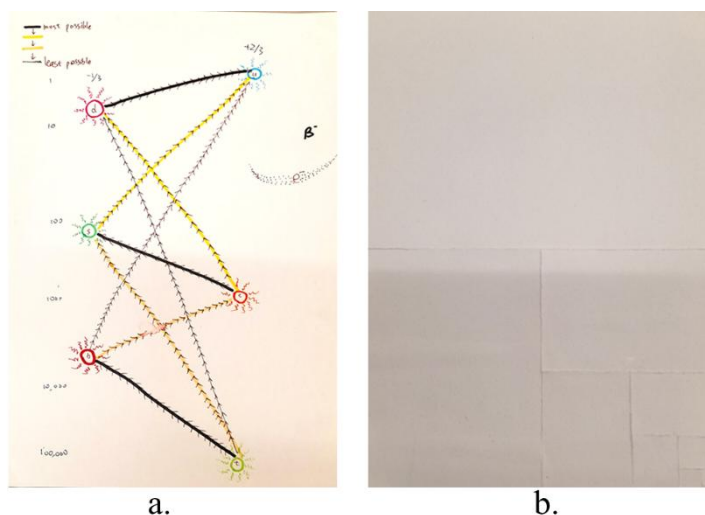


Figure 11 Two artwork about the strong force. Photograph by the author, 2023.

Different-sized white square paper pieces are arranged in a very geometric way by the golden ratio. In his work, the artist wanted to show how our material world is always fragmented into smaller particles, and that there are always smaller particles to find. The Artist makes very philosophical statements about nature with her art. Quantum mechanical laws with allowed and prohibited transitions formulate the strong force. In Figure 11a, participants make clever and playful illustrations of different transition or decay combinations involving different quarks.

In summary, small artworks based on the strong force succeeded very well. Participants found topics easy to execute on a fast page. This exercise was designed mostly to introduce the first experience to SciArt and the scientific illustration process, and I think that every picture presents its ideas very well. This kind of exercise about nuclear forces is highly effective. I also like to document my own feelings. When I see these pictures at the end of the second meeting, I know that this workshop is going well.

String theory

The third meeting's theme was about String theory. After the lecture on the topic, participants created artworks based on it, and during this time, they had full freedom to do what they

liked with it. All works have aspects or strong resemblances to strings or springs. In many works, the 3-dimensional aspect of that theory is undeniable. That theory is notorious for using extra dimensions up to 11, or sometimes more, in its mathematical construction. Several works are collected in the next two pictures.



Figure 13. Two String Theory artworks. Photograph by the author, 2023.



Figure 12. Another two String Theory artworks. Photograph by the author, 2023.

Several observations arise when those works are seen. Strong dimensional execution and colourful materials. They definitely have inspiration from String-like pictures that can be seen in Figure 6 in Chapter 5. Clearly, participants choose to play with different 3-

dimensional shapes. All participants make very illustrative artworks, and exercises like this can be recommended for future use. String theory works would be very interesting to test at different levels in education, because it can exemplify objects' multidimensional properties better than 2-dimensional pictures.

5.3.2 Exhibition Works

As mentioned earlier, every work in the exhibition represents the maker's background, artistic preferences, and medium. Designers who gravitated to more design-oriented and artistic/handcrafts favoured art- or material-oriented approaches in their pieces. These exhibition works were also the final works for the workshop course. One work that was not in the exhibition is also in the following series of final works.

Exhibition works were well crafted, and the exhibition works indicate a long evolution and design process. A wide variety of techniques and media were used in the execution of the works. Participants gave short reports of progress in the feedback query, and most participants had a clear view of the final works after the workshop days. The resemblance of planning state pictures to final works was very clear. Clearly, all participants found their own themes by themselves easily, and that is a good indication or result for this workshop model. Everybody gets a clear view of what SciArt is as an art form, and can make art from very complicated or challenging physical topics. I think that after only 4 gatherings, participants get enough information and experience to make exhibition-level art.

To me, there is a lot of artistic freedom in choosing the subject and artistic thinking. These exhibition works were also the final work for the workshop course. In the artwork, which is Figure 14, the artist experimented with a group of three lamps. Three colours, red, green, and blue, are chosen from the strong force theory (Chapter 4) to represent 3 different polarities that quarks represent. Each lamp hangs on its own thread, but all lamps are interacting with each other like quarks.



Figure 14. Lamp design inspired by the strong force. Photograph by the author,2023.

String theory was the subject of the triptych with spherical figures (objects like strings) that interlink parts of the work. See Figure 15. Artists have explored 3-dimensional objects with interesting colour codes resembling strong force colour coding. Spherical essemles binds different surfaces together: A hint for interlinking dimensions with strings?



Figure 15. Triptych inspired by String theory. Photograph by the author,2023.

Figure 16. has two works that have strong mathematical or geometrical influence. Symmetrical balance or harmony are complaint with the spherical shape. Figure 16a has a very symmetrical, complex figure, resembling a flower with different scientific fractals.

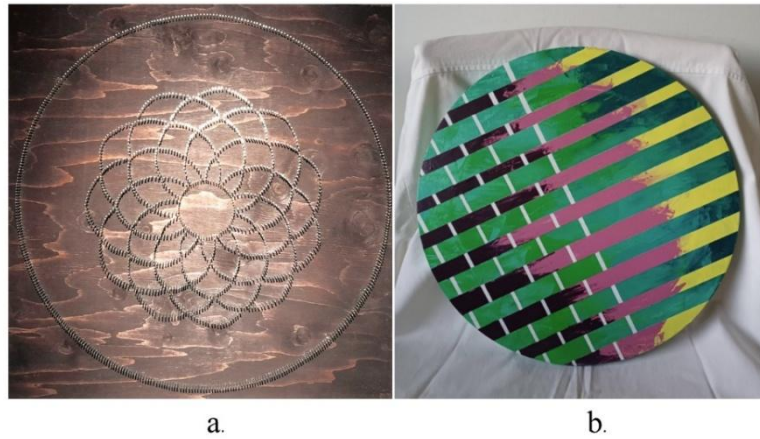


Figure 16. Two geometrically oriented artworks. Photograph by the author, 2023.

Figure 16b has a strong multi-layer essence. Straight lines that cross each other give a strong feeling of concentrating on one layer in time. Just like zooming in on different microscopic length scales. I tend to think these two are good examples of Marh Art also, and they have some attributes that resemble Penrose tiling. See Chapter 2, Figure 4.

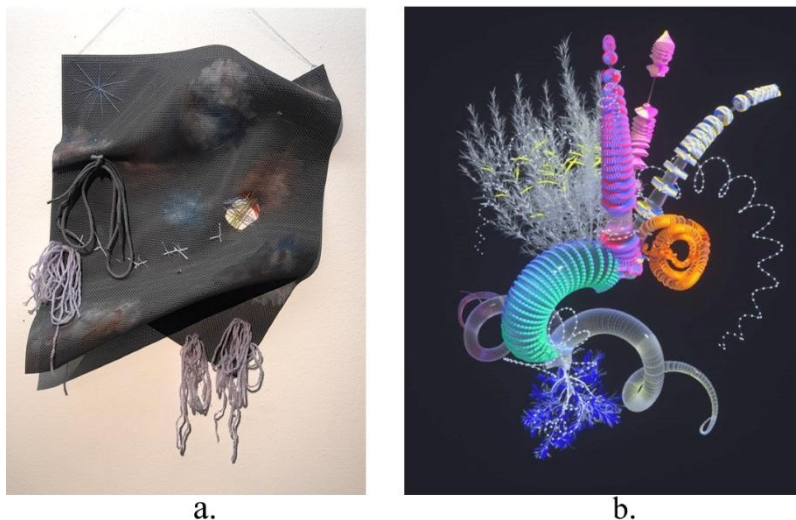


Figure 17. Two elastic and amorphous artworks. Photograph by the author, 2023.

In contrast to previous works with precise mathematical order, in the next two artworks, the artists choose to execute in a very plastic and free-form way. In Figure 18a, there is a strong

3-dimensional arrangement of a web with embroidered objects. This work has a lot of moving qualities. Figure 18 b. is a snapshot of an animation that takes inspiration from particle reactions. In this picture, every particle is represented as a flower of feather-like structures. These four artworks (in Figures 17 and 18) resemble to me about two different sides of science, from very well-defined structures and spatial order to softer and amorphous structures. Both sides can be found in nature and also in highly defined theories.

Summary for Exhibition works

Exhibition works were well-crafted and indicated a long evolution and design process. A wide variety of techniques and media were used in the execution of the works. Participants provided brief progress reports in the feedback query, and most have a clear view of the final work after the workshop days. The resemblance of planning state pictures to final works was very clear. Clearly, all participants find their own themes by themselves easily, and that is a good indication or result for this workshop model. Everybody gets a clear view of what SciArt is as an art form and can make art from very complicated or challenging physical topics. I think that after only 4 gatherings, participants get the information and experience to make exhibition-level art. I can recommend the SciArt workshop as a promotional or educational tool to all artists, art students, and art enthusiasts.

To answer, can a SciArt-based workshop be a good tool to promote Science to the public? The answer is yes. Also, based on research in this thesis, I find that exhibitions thematically focusing on SciArt also uniquely promote science to the public. These exhibition works are done after feedback queries, but they validate and prove a lot of findings for the research questions.

5.3.3 My own impression as a physicist

As a physicist, it was interesting to find out, and frankly, to my surprise, that participants chose several abstract physical concepts for their ideas for artmaking. Even though the physical accuracy of artworks was not a target or research topic for this workshop, it was fascinating to realise how close they were to scientific predictions, and the very playful attitude of participants to artmaking was very strong. Definitely, artists take a lot of freedom, use colours boldly, compose and exaggerate freely, but many times the source or idea is still

noticeable. Artworks have a lot of mathematical geometry that is the foundation of many physical theories.

In particular, the works on the strong force were interesting. Usually, protons are illustrated as a geometrical sphere, but in workshop works (Figure 10), they are presented in other forms. I tend to think that protons are very deformed objects, as in the next link (University of Washington, 2003). Actually, why is a proton always pictured as a spherical shape when it is not? A strong message to physicists and scientific illustrators.

Also, the inner structure in those proton (or neutron) illustrations is interesting. The strong force is a very complicated force that exhibits many interaction structures inside protons. Many works have very interesting suggestions, from curling fields to complicated webs. I feel they can be very useful in scientific illustration, as a way of representing forces that are moving and whose spatial strengths are not constant. Somehow, I find a lot of similarities between these artworks and recent animations for proton structure theories. Especially in the following link (Quanta Magazine, 2022).

Many 3-dimensional string theory artworks are fascinating in many ways. Firstly, they are very colourful, but also educational and illustrative. To me, one complicated concept in string theory is understanding vibrational modes in strings. They are easier to visualise when watching a real 3-dimensional ensemble.

In some works, there are hints of complicated multi-dimensional interlinking with fields. I don't know if the artist who made an ensemble with blue strings and folded papers was familiar with D-brane string theory, but the ensemble has similarities with a picture presenting a D-membrane (Wikipedia, D-brane, 2007). To make this thesis compact, I present only a couple of ideas from exhibition works, even though every work has an interesting interpretation of physical concepts. In his artwork, figure 18a, the artist makes very clever use of the brown canvas, which has a strong resemblance to a quantum mechanical field. I suggest watching the next YouTube video from 7min onward (YouTube, 2023); the similarity is obvious. All embroidered objects are just like different kinds of particles moving in a force field.

Symmetrical objects and shapes, like mostly spherical shapes or objects, can be seen in many exhibition works. To me, it's very natural because spherical or geometrical shapes are seen in nature all the time. Are we drawn automatically to geometrical shapes and round objects when making art about something that takes inspiration from nature? Good question for future research.

5.4 Summa Summorum

I think it is good that we summarise all findings and analyses here. Participants find similarities between art and science through their personal experience, and they find that scientists and artists have the same kind of curiosity that motivates both. The scientific topics seem to be understood very well; artists also find inspiration to do their art for the exhibition with an excellent SciArt vibe. Participants reported that they learned something new about physics, too. All art done in this workshop has strong connections to physics, and the inspiration or topic is also visible in all the art done. Physical objects or phenomena are clearly present in most of the artworks. Participants felt that art can be useful in science-making and can bring something new to the table. To validate this belief, some artworks, at least to me, have very useful suggestions to explore by scientists or scientific illustrators. The tested science-based art workshop model is good to use in future, and I think it is easy to modify for different uses.

5.5 Participatory part in the exhibition

My original idea was that this picture was not a part of this thesis, but I feel that it should also be included as an additional picture, even though it is not used in the analysis. It deserves to be published. It has that clever playfulness that was also part of the atmosphere in the workshop and exhibition. It's a green canvas, on which visitors were able to construct their own formulas with white charcoal. The idea is that it humorously evokes school days, when green chalkboards were used in education purposes, and students used to write anonymous secret messages or their own formulas to others. Visitors' formulas have references ranging from heartaches to environmental statements. Definitely, formulas cover many aspects of life for modern students.

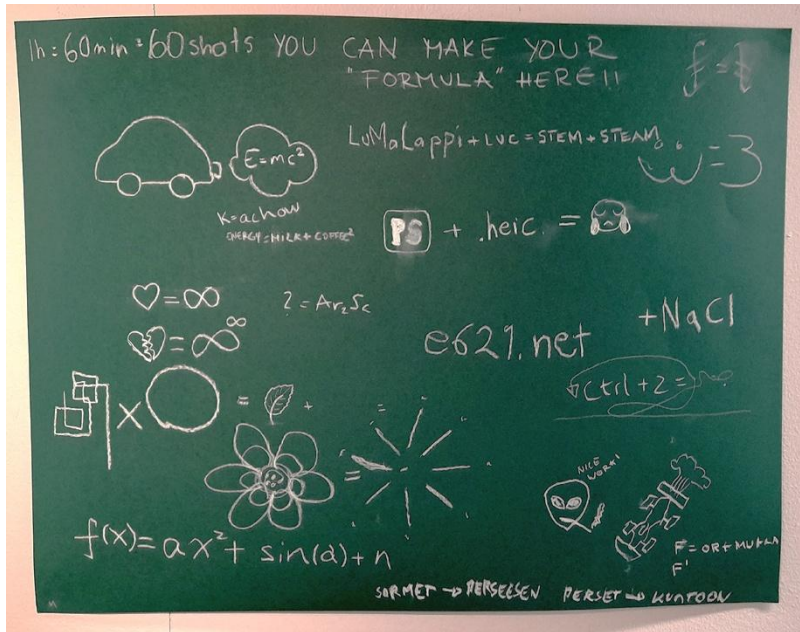


Figure 18. Partisipation part of exchipation: Real lifes formulas. Photograph by the author, 2023.

5.6 Criticism of the workshop process

If the whole workshop process, from the first Gallup for scientific themes to the end of the exhibition, is critically viewed, the workshop model works reasonably well, and it gives good results for research questions, and participants were pleased with the opportunity to try something new. Also, it gives a new inspirational perspective to the science world, and it worked very well to promote science and the SciArt trend as well. But several small changes might be interesting to discuss, especially for those who are planning similar workshops or SciArt-based art activities.

5.6.1 Subjects for the science part

The scientific themes for this workshop are challenging. From feedback, I found out that some participants had doubts about understanding science in general. If a person is not sure that he understands science properly, he might be afraid to do art with it. I understand that mindset. Materials and lectures that might be presented in similar workshops should be simple and easy to understand.

The same dilemma can be an issue for a workshop facilitator. Many modern introductory-level textbooks about subjects (e.g., particle physics and string theory) are technically challenging and pictures or ways of illustrating things are, for lack of a better term, “old-fashioned” and resemble more like chalkboard drawings. That can be an issue if candidates for the SciArt workshop are struggling to understand topics and collect visual material for workshops. Of course, I understand the traditions in studying ways in colleges and universities, but well-crafted and designed illustrative pictures can be very helpful for students at any academic level and in all faculties. Surely, there is a need for quality scientific illustrations, and so there is a need for science-oriented artists.

So, my advice to SciArt workshop facilitators would be very controversial. It is possible to use materials other than academic textbooks in preparation for workshops. When I was collecting materials for lectures, I found out that many internet sites are run by scientific organisations and the accuracy of materials is kept to high standards, and materials are selected to be easily understood. During my experience collecting materials for these workshops, I found that many internet magazines and science organisations' YouTube channels are an excellent choice for collecting materials for lectures. They can even be artistically or visually made with very high standards, if we compare them to university-level textbooks. It looks like those organisations use professional artists to make their materials. Like the Fermilab YouTube channel (Fermilab, 2026). Also, I think that artists who want to concentrate on making art that takes inspiration from science can trust that the information they see is scientifically correct.

Based on this workshop, I believe very strongly that an artist (who has not studied science at the university level) can make informationally relevant illustrations about topics that are out of our observational scope. Surely, if an artist plans to do science illustration professionally, it may need more than “a couple of 1-hour lectures”, but more conversations with people in the science field and studying subjects more can give artists enough confidence. That is, of course, when artists are making professional material for a scientific society or the media.

Of course, if we think from an artistic perspective, artists have their own artistic freedom to interpret the subject and develop their ideas in abstract or other directions. From this point of view, it's also possible to recommend a science-based art workshop to give ideas and inspiration for their art careers.

In this workshop, scientific topics were chosen from a “modern top science perspective”, but they can also be chosen to represent other fields or results. Especially biology or ecology

can be a good choice. If the workshop group is younger than university or college students, it would be wise to consider more easily understandable subjects. But on the other hand, science with peculiar phenomena can be a very inspirational theme.

Several aspects of SciArt can be interesting to include in the workshop curriculum in future. Based on the discussion during the workshop, new topics can be philosophical or theoretical aspects of SciArt. Linking to philosophical evolution through history, from Aristoteles to Da Vinci and to our times. The history of SciArt is also an interesting theme linking to art history and the history of science. But also, more deeply into Scientific Illustration, its traditions, history, philosophy and several real visual exercises.

5.6.2 Structure of workshop and feedback queries

Some changes can also be recommended for the structure of the workshop. Depending on the timetable, workshop meetings would be in the late afternoon after other lectures. Based on some discussions with fellow art students, some had overlaps with mandatory courses. A couple of participants hoped for more lectures. If I were to facilitate a similar workshop again with more time, I would like to include more lectures about SciArt as a trend and its history.

My own feelings at the beginning of the workshop process were that participants could express their experiences and feelings freely in the feedback questions. That worked very well and gave a lot of insight into participants' experiences. But in cases with more participants, like 15 or more, it is advisable to structure the questions so that answers are shorter. That is, of course, a matter of time to analyse the answers. Also, depending on the situation, I will consider deepening questions only on one or two topics.

5.7 Need for SciArt and an Artist's role in future

Of course, this question is not a research topic in this thesis; I somehow feel that this topic should be discussed to some degree in this work. In chapter 2, we discuss the role of artists in the SciArt field and prospects for SciArt and scientific illustration. Based on the experience of this workshop, some comments on this topic can be discussed. There is a

multitude of studies that predict the need for artists in the science world in future (Nature, 2021; Røstvik, 2016; Fleerackers et al., 2022; Greaves et al., 2025). Definitely, this gives possibilities for artists to choose between different roles in the field. On the Artistic Road, artists can find a way to criticise science, or, on the other hand, artists can specialise in scientific illustrations with accurate information. There are other possibilities, like specialising in community art-oriented SciArt topics or even practising art-research in the SciArt area. So, working in SciArt can give several relevant career choices for artists, or at least it can be partially source of income in future. Based on experience and results of this research, SciArt workshops (perhaps similar courses) are good methods for artists to gain confidence and basic knowledge to seek opportunities in the field. Workshops can give more freedom for group work, and mutual experience can help to understand science.

It is also recommended that, in this kind of SciArt workshops also be lectures about different roads or artists' approaches that participants can follow. Critical or philosophical approaches can also be one theme to consider.

5.8 What I learned in this workshop process personally

On a personal level, as an artist and facilitator, I am much more confident in how to organise the whole process from beginning to end. Also, as art-researcher I know how to organize research and how to construct feedback questions to suit research questions and the analysis stage in mind. As well, I know how to keep things going in workshops and during artmaking. But during this process, I also find new kinds of joy and enthusiasm in science, and particularly in physics. Of course, my art studies can affect this “new enthusiasm”, but this was my first real contact with SciArt. I think participants' genuine fascinations about the topic also affected me positively, and I see things from their perspective. To me, it's like a new door or aspect of physics opened to me. Based on my personal experience, I think that scientists benefit from this kind of art activity where they visualise and make art. It can be a very positive, inspirational effect, and some can find new enjoyment or a new angle to see their work. At least, to me, it has this kind of effect (I hope it will last ☺). My own interest in the philosophical aspects of SciArt or interlinking art and science increased, and I see that these topics will be researched on a wider scale globally. So, I will be following these topics after my graduation.

6. Conclusions

For this thesis, I facilitated a SciArt (science-based art) workshop for university-level art students and analysed written feedback and artworks done by workshop participants. I used research methods commonly used in art research, namely ABAR and ABR (methods that have been successfully tested in my home Faculty over the last decades). My research questions were about how participants experience the connections and similarities between science and art. Also, I researched whether participants could find any similarities between scientists' and artists' approaches to their work.

I found that making art from scientific topics can give personal-level insights into the similarities between art and science. Participants find common factors between artists' and scientists' mindsets, especially that the driving force to understand the world is mutual for both sides. Also, participants see potential in collaboration between Art and Science and believe that art can help science evolve.

I also studied: Can artmaking help to understand very theoretical and abstract physical concepts? I find that SciArt workshops can offer participants unique opportunities to understand natural phenomena and deepen their understanding of our physical world, which aligns with several studies. That is also very encouraging if we think of development possibilities for art workshops with difficult scientific themes, like quantum mechanics and relativistic theories. I believe that this kind of workshop can give a positive attitude toward science and enjoyment of personal growth and understanding of the cosmos.

An extra research question that arose during the analysis phase of this research. Can a tested workshop concept be used for different academic purposes, such as promoting scientific illustration and SciArt as an interesting art form, and serving as an educational tool for other purposes?

Based on my findings, SciArt workshops can be an effective way to introduce professional (or student-level) artists to the field of Scientific Illustration and to SciArt itself. Of course, workshop models can be easily modified into longer courses by extending time periods and themes, such as history and philosophy, and incorporating several practical exercises. But I think, as a compact model, it can be easy to integrate into curricula, such as a summer course.

I would like to see the science and art worlds approach and find some common ground to collaborate in future. I think that positive experiences can help with that, so SciArt

workshops are a good method for that. I would like to state that SciArt workshops are good stepping stones for those who, people outside of the art and science communities, have a natural curiosity for it as an art trend or even science. Questions about the philosophical side of SciArt, or just what SciArt is anyway, will be a good theme in similar workshops and can give participants confidence to continue developing their own SciArt adventure.

All findings in this thesis can be valuable information to develop SciArt workshops further, and I believe this theme about similarities would interest people outside of the science and art community. I strongly believe that these commonalities can be good promotional tools for introducing science and art. I hope that in the future SciArt helps to overcome someone's hesitation to dwell to world of science or the world of art, or into both worlds.

6.1 Further developments for the workshop topics

The SciArt workshop model, with a strong emphasis on scientific topics, is easy to conduct and prepare and can be warmly recommended for future use. Surely, this workshop topic was like jumping into the “deep end of physics,” but workshop topics can be more approachable, like biology or ecology.

In this workshop, the internal theme was how to illustrate the physical world and its phenomena that are not possible to see or observe directly with scientific measurement. That seems to be an interesting and very inspirational idea, and it leads to interesting artworks with flourishing personal styles. It is also good advice to look into other science-based ideas for workshops. For those who seek these kinds of themes more, biology has a lot of interesting phenomena, like photosynthesis, which are essential for biological life. It is also a phenomenon that we don't see.

Of course, to me, as a physician, it was naturally easy to give a lecture about higher-level physical concepts, but my impression is that any artist can facilitate workshops that involve science and abstract concepts. My own idea was that lectures are easy to follow, and abstract concepts are taught without heavy mathematics or formulas. I collected material for lectures and additional reference lists from common sources, like science institutions' web materials (YouTube, home sites, and so on). The scientific accuracy of the materials is excellent because they are usually maintained by scientists themselves, and I believe that, for workshop materials, even Wikipedia is an accurate source. To conclude, there is no need to

read textbooks or study hard to keep up with lectures. I hope that this result can help someone lower the threshold to conduct similar workshops.

6.2 Improvement for the workshop model

If somebody is planning a similar workshop, some suggestions can be given based on the experience of this workshop. Four gatherings in a period of two weeks seem to work well, but they were conducted in a short period between the end of university courses and the Christmas holiday period. If workshops were managed during lecture periods (semester, spring), the time window for lectures and meetings should be longer, due to the probability of overlapping courses. Also, most of the students are in situ during the usual study month. Some students most likely start the holiday season before December. In my experience, intensive SciArt workshops can be a good candidate for a summer course.

Luckily, every participant finds inspiration for artwork easily, but it would be advisable to have some voluntary meetings before the exhibition. Finding ideas or trusting one's own ideas for art is sometimes challenging. I tend to think, based on my own experience as a natural scientist, that sometimes concepts are not easy to understand at first glance, so facilitators should take this into account during the workshop period.

But I find that when participants can affect, at least a little bit, what topics the lectures are, it can give a more positive attitude toward the work. It is very easy to conduct an anonymous Gallup online survey, with pre-selected topics to choose from. Also, the exhibition process, preparing artworks for the opening, was a highlight in these workshops. Feedback from participants and the audience was highly positive.

6.3 Some new research topics

Some other research topics arose during the making of this thesis that can utilise the same research strategy: SciArt-based workshops with ABR, ABAR or other research methods. One is: Can ecological values change if the topic is ecology or environmental issues? This topic seems relevant to our time due to the condition of the environment. Philosophical and practical similarities between art and science can be studied further with similar workshops. More deeply and on a personal level.

I see the SciArt art trend and scientific illustration as an independent art activity with its own philosophy, aesthetic values, history and conceptual identity. Also, there is a continuum between these two, where SciArt aspects and scientific aspects can mix in artwork without boundaries. The existence of this continuum can give a lot of new research questions, like: where is the border between scientific illustration?

Also, a fascinating idea would be to study the aesthetic differences and uniqueness of SciArt if we compare it to art and to the aesthetic attributes of science itself. Of course, these groups of topics can be treated theoretically, but it would be interesting to explore these questions experimentally in art workshops. Can SciArt be its own culture with its own unique research methods in the future? I have a strong feeling it will be, based on the literature on the subject.

6.4 Recommendations for further developments

Based on the experience of this research process, we can suggest different art-based development projects if somebody is interested. The Finnish school systems have already had well-established educational art curricula from primary to high school levels, but is it possible to bring SciArt-based art activity to other educational levels? Universities, Universities of Applied Science or vocational colleges?

To my understanding, there are no SciArt courses frequently facilitated in Finnish higher education institutions. With that in mind, based on my research, several different university-level courses can be developed from the results and experience from this workshop. One motivation for further development is that in modern-day society, artists are suffering from economic limitations and limited opportunities. So new career possibilities are needed.

For designers, especially graphic designers or audiovisual-oriented artists, tailored courses can be useful in future. Science-based magazines, books and media are already an important aspect of everyday life, and the need for artists to specialise in accurate scientific information will be important. Themes to concentrate on can be scientific accuracy, how to demonstrate phenomena and how to illustrate scientific topics so that they are easily understood.

Designers who will work in industrial design, in the fashion world, or in handicrafts can have tailored courses in their curriculum. It's well known that inspirations for design are often taken from nature and its phenomena. New fabric patterns or tableware can have

inspiration from science, and designers can produce something that stands out positively from others in competition.

Educators, like art or science teachers, can have SciArt in their arsenal to activate or motivate their students, also as a secret weapon to deal with otherwise unmotivated students, like teen boys.

Many universities of applied sciences have many bachelor's programs in technology faculties with a lot of scientific and technology-oriented topics in their curriculum. Is it possible to bring art-based action to those studies? In modern times, art-based skills are expected to increase in the work culture, and they provide more needed work opportunities. Scientists, engineers and technical people often must make illustrations, pictures and such for their research papers, posters, columns, and exhibitions. It is also relatively easy to design different courses for them.

Scientific Illustration can be a relevant career choice for several art or science students. While writing this thesis, I didn't find any relevant courses in Finland's higher education system. In Finland, there are about 38 higher education institutions. The number of universities is 14, and Universities of Applied Sciences are 24. Surely, there can be some "promotion prospects".

SciArt and SciArt workshops might be good ways to introduce applied art to different organisations. I have that strong impression that SciArt-related activities would be beneficial to industrial companies or other organisations. Science-based topics and materials are more accessible to industrial or technology-oriented groups due to familiarity towards science, because technology is heavily rooted in science. SciArt can be a "so-called icebreaker" or a bridge to a more art-based innovation work culture. In Finland, we can predict that the number of industrial companies is several hundred, and the number of different scientific specialist organisations is probably several tens or more.

7. Use of AI

In some cases, AI is used in the process of writing this thesis: to promote the correctness of language, Grammarly on-line free version is used. Also, for advanced searching of articles, Copilot and ChatGPT were used occasionally.

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