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Why We Need Engineers to Make Art

Giovanni INNELLA[a*] and Paul A. RODGERS[b]

[a] Advanced Institute of Industrial Technology
[b] Lancaster University
* Corresponding author e-mail: g-innella@aiit.ac.jp
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As design practitioners researchers and educators, we constantly find ourselves shuffled between humanities and sciences. In fact, the design departments in the universities around the globe are sometimes placed under the formers, sometimes under the latters, thus becoming a meeting point for academics and professionals coming from both realms. The synergy resulting from the varieties of backgrounds and expertise creates a fertile ground for explorations on both a conceptual and a technical level. This paper reflects on the potential benefits of combining engineering and art research. The authors of this paper look at the increasingly delicate role that technicians, engineers and computer programmers play in developing technologies that impact our social, emotional and intimal lives, and advocate for art as a context and tool to help those professional developing their sensitivity and critical sense, besides their skills. In doing so, the paper makes a contribution to the STEM vs. STEAM conundrum, encouraging an education that merges arts and humanities disciplines with scientific and technical subjects.

Art; Engineering; indisciplinarity; STEAM.

1. Introduction and Historic Background

If one looks at the way conventional educational and academic contexts have been conceived and organized, artistic and engineering disciplines seem to be two very separated realms. In fact, art and engineering schools, events and qualifications rarely co-mingle and most of the time only out of necessity, rather than out of a true will of exploring the potential of such a contamination. However, historians suggest that such a separation has not always been there.

During the Renaissance (1300 – 1700), artistic and scientific research seemed to go hand in hand. The intellectual man of the Renaissance was a “polymath”, someone who could span art and engineering, design and mathematics, philosophy and science. Many suggest Leonardo da Vinci as the archetype of the polymath; one of the greatest example of the Renaissance Man. In fact, he could work on projects where the artistic and the scientific research and practice merged, to the point that it was hard to discern the two or label the author as either an artist or scientist (Figure

1)(Jones, 2012; Pitenis et al., 2014). Interestingly, many of the Leonardo Da Vinci's studies on anatomy, optics, perspectives, mechanics, production processes were aimed to the making of artworks, whether paintings, sculptures or architectures(Léonard de Vinci et al., 1997). In some ways, we can state that for Leonardo art was the drive and the mean to conduct his research.

As Wilson (2014) suggests, the current separation between science and the creative arts is a consequence of the Enlightenment and the Romanticism movements of the XIX Century. While Enlightenment pinned its hopes on logical thinking and scientific progress, as a reaction, those joining the Romanticist movement gravitated towards emotion and feelings and which manifested through the arts. As a result of these two opposite forces, the distance between the two spheres was highlighted, in spite of the convergence of humanities and science witnessed during the European Renaissance. Since then, we stubbornly separate the science from humanities, engineering from arts, technical skills from conceptual thinking. Two centuries later, we still strive to mend such a tear, however not without difficulties.

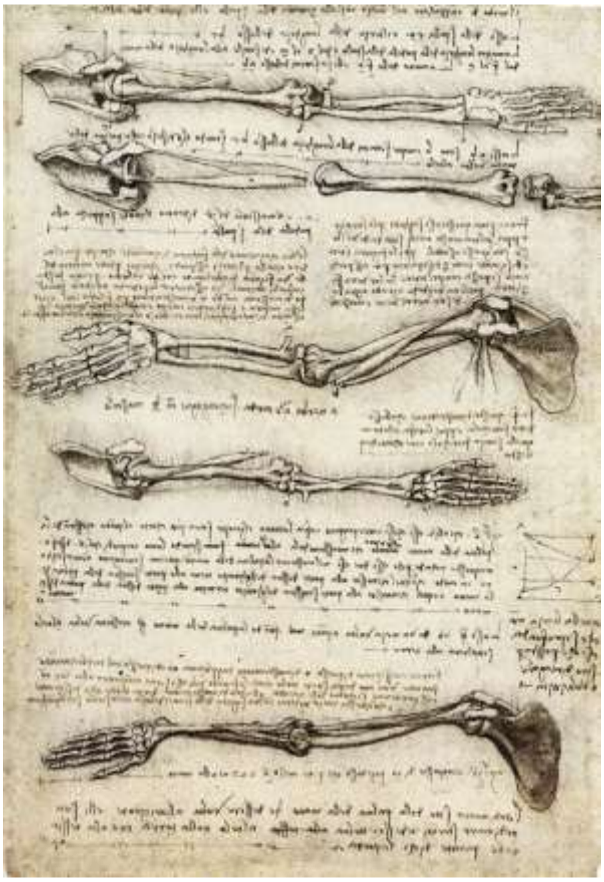

Figure 1 Studies of the Arm showing the Movements made by Biceps, c. 1510, a drawing by Leonardo da Vinci. Source: http://www.drawingsofleonardo.org

2. The Gap Between Art and Engineering in Education

It would not be for nearly 500 years, from the rise of the universities and cities of the later Middle Ages, that the first formal education system to promote a mix of engineering and art, the Bauhaus, would appear and open its doors for the first time. The Bauhaus, with its roots in the Kindergarten system of educating young school children perfected by Friedrich Froebel (1782 - 1851), gave rise to a number of "Masters" including Johannes Itten, Josef Albers, and Paul Klee. These individuals and others infused the Bauhaus' revolutionary *Vorkurs* programme of abstract-design activities, with an emphasis that owed a substantial debt to Froebel's Kindergarten system. In 1919 Walter Gropius was appointed head of the Bauhaus in Weimar, Germany. One of Gropius' key objectives was to integrate art and economics, and add an element of engineering to art. As such, students at the

Bauhaus were trained by both artists and master craftsmen in an attempt to make "*…modern artists familiar with science and economics, [that] began to unite creative imagination with a practical knowledge of craftsmanship, and thus to develop a new sense of functional design.*" (Bayer, Gropius, & Gropius, 1952: 13). The main aim of the Bauhaus was to "*…rescue all of the arts from the isolation in which each then found itself...*" (Whitford, 1984: 11)and to encourage the individual artisans and craftsmen to work collaboratively and combine all of their skills. The Bauhaus also set out to elevate the status of crafts to the same level enjoyed by fine arts such as painting and sculpting. Ultimately, the goal was to maintain contact with the leaders of industry and craft in an attempt to gain independence from government support by selling their output directly to industry.

Nowadays, most schools reflect the rather sharp division between artistic and engineering disciplines. The rigid division of faculties and departments is a sign of such a separation. It is commonplace for art schools not to include engineering courses in their curricula. Similarly, engineering institutes look at art as a far away world, populated by very differently minded professionals (Zald, 1993).

There are, of course, examples of organizations that bring together the art and engineering worlds, through interdisciplinary teams and processes (i.e. MediaLab, Copenhagen Institute of Interaction Design, Interaction Design Institute of Ivrea, the Royal College of Art and some others) (Ortony, 2003)(Smith, 2007). For example, the now defunct Interaction Design Institute of Ivrea used to enrol students coming from both technical backgrounds, such as informatics, mathematics and engineering, and humanistic backgrounds, such as communication sciences, art and design. The former students were asked to take classes on humanistic and creative subjects, while the latter students had to attend technical courses on programming and electronics. In this way, the institute thought of bridging – or at least narrowing – the gap between the two types of students. The impact of this simple decision was limited, though still appreciable. Thanks to such a diverse education, graduates from the Interaction Design Institute of Ivrea went on to work indistinctively in the arts (i.e. Pors & Rao) (Shackelford, 2012), for technology companies such as Philips and Google, or contributed on innovative engineering projects – Arduino was conceived and developed by people working or studying in the institute) (Frauenfelder, 2011).

Apart from the aforementioned examples, few exceptions exist that do not retain the orthodox separation that sees arts belonging to the humanistic sphere and engineering as part of the scientific domain. This separation is commonly accepted in our educational cultures – certainly in the West – and is also seen throughout our scholastic systems.

Besides the way our culture is shaped, the separation in our schools between the sciences and the humanities is dictated by a number of practical reasons. Among these reasons there is the necessity to organize staff and students, optimize the use of spaces and facilities, award students with more specific academic degrees in order to arguably improve their employability in the professional world. However, such issues should be overcome in order to provide a more holistic education and a better flux among different types of knowledge and thinking.

3. The Gap Between Art and Engineering in Practice

Outside the environments of art and design schools and formal education systems, the separation between the technical and the artistic is much less evident. Of course most art practitioners are labelled as artists and are placed under the umbrella of humanities, whereas engineering practitioners are seen as technical professionals and find their place more in the scientific fields. In recent years, however, the development and widespread use of readily available information and computing technologies to create artworks has helped bridge the apparent gap between art and engineering (Rodgers & Smyth, 2010).

If stating that every art piece has to be designed, engineered and ultimately fabricated may sound obvious, the active involvement of engineering skills and research in art becomes more embedded in the art process when thinking of kinetic sculptures or interactive installations, for example. In fact, in the case of kinetic sculptures and interactive installations, the artists have to learn how certain technologies work, get inspired by their potential and shape their own thinking around those factors. At the same time, engineers and developers have to understand the artistic concepts, push the technological limitations to achieve the desired results or offer viable options for the project development. In the way, the process can be seen as a flux of notions and processes, in which engineers and artists challenge and inspire each other while working on real projects (Yilmaz, 2014).

1. Many hybrid practices have arisen at the intersection between art and engineering. Many of them have a more artistic lead. This is the case of British studios such as Troika (Figure 1, 2 and 3) and Greyworld, the Paris-based creative collective HeHe and the Japanese offices TeamLab and Rhizomatiks, for example. There are also the longer-established art studios of Olafur Eliasson (Germany) or James Turrell (USA).

Figure 2 Kinetic sculpture "The Cloud" by Troika at Terminal 5 o Heathrow Airport, London. Source: http://www.troika.co.uk

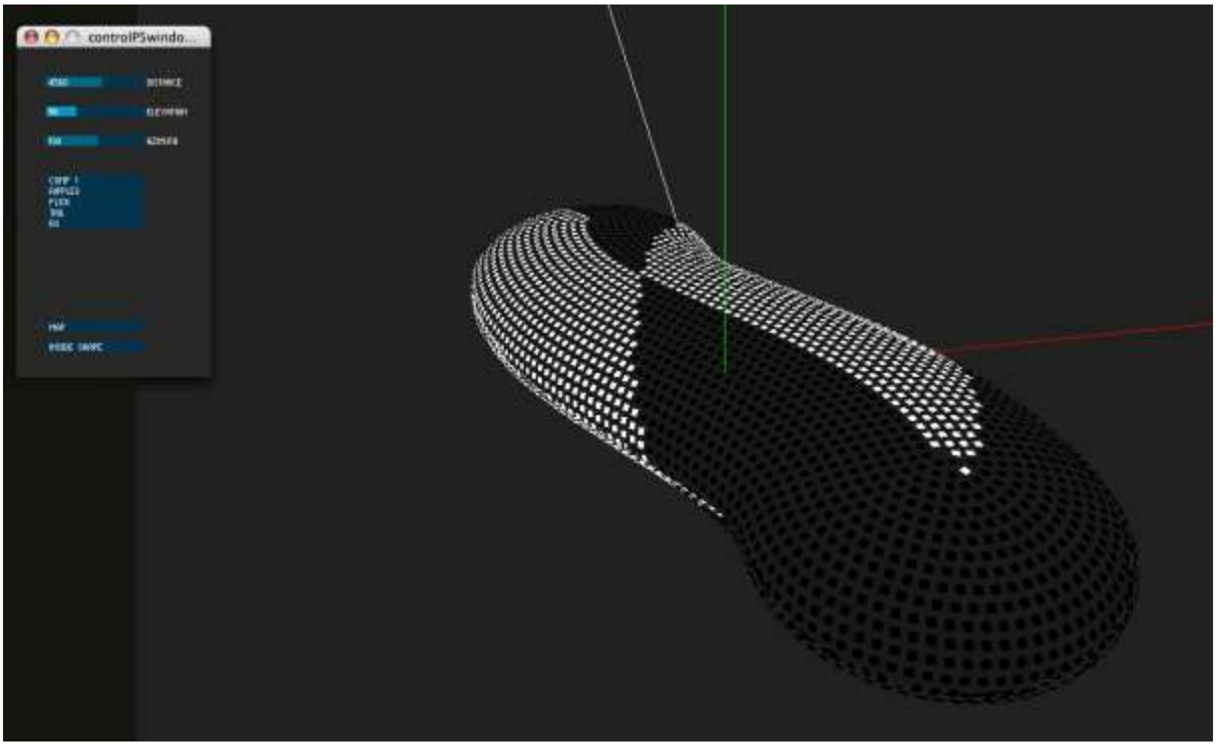

Figure 3 Programming of "The Cloud". Source: http://www.pixelsumo.com

Figure 4 Making of "The Cloud". Source: http://www.mikesmithstudio.com

But there are also engineers that rediscovered themselves as artists. Moritz Waldemeyer is among them. Waldemeyer started as a tech consultant for the conceptual fashion designer Husseim Chalayan, before launching his own creative practice. These studios usually begin their projects with an artistic approach, to then start a conversation with technicians and scientists to explore what technology allows them to make. This is when projects may take different routes by pulling and pushing between technological possibilities and artistic explorations. In this process, technical companies, whose expertise lays in engineering and fabricating artworks, are often involved.

4. STEM vs. STEAM

In the last decades, educational curricula have mostly favoured a model based on Science, Technology, Engineering, and Mathematics (STEM), which integrates the four disciplines in combined programs, without the sovereignty of one of the four. Those subjects prepare and expose students to different ways of thinking and introduce them to a wide range of careers. Educating our pupils to scientific subjects arguably improves their decision-making abilities, their logic skills and it is also profitable for our economies, thus allowing the students to access secure and well-paid jobs (Atkinson & Mayo, 2010). Statistics tell us in fact that jobs that require scientific knowledge and technical skills are simply more in numbers, significantly better paid and generally more highly regarded by people of developed countries (Dishman, 2016; Provencio, 2015). Fundamentally, the STEM system simply supports the economies we live in, instead of exploring new social and economic models. Notably, the STEM educational system does not aim to bring together humanities and science, but more simply overcome boundaries within the scientific realms.

More recently, the importance of arts for a well-rounded education has been brought into the discussion and the acronym STEAM – where the A stands for arts – has taken on ever-greater significance. Those who push for a stronger involvement of the arts within the scientific-technical education see an opportunity to enhance some soft skills of the students, ranging from sense for aesthetics, real-world applications, playfulness, and communication (Kim & Park, 2012; Land, 2013). Recently, the State University of New York in Potsdam has investigated the potential of a STEAM education with the intention of creating *“a model for the education of scientists who will be able to create innovations in modern science and technology necessary to address the complex problems facing human society”* (Madden et al., 2013).

In the discourse about education, it is being advocated that there is a bit of art in all the scientific subjects and that including design, performing arts and creative planning in the curricula produces more creative, communicative and organized students. In this paper, we try to go beyond the technicalities of how a STEAM model should work in order to reflect on why the arts can represent a context and a tool to train citizens that can more meaningfully contribute to our contemporary and forthcoming societies.

5. A World of Algorithms

From the perspective of a creative practitioner – whether designer or artist – the engineer or scientist might seem just as a helper, a problem-solver, a little wizard that makes things become real or that can open the doors to technical and scientific wonders to exploit. This is possibly an incorrect and limited view of what an engineer, a programmer, a scientist, or a technician is and might be in the future.

The world we live in is increasingly ruled by technology. The permeation of a variety of different technologies in our lives is not a recent phenomenon. Our homes, our appliances, our vehicles have always evolved from a technological perspective, becoming more comfortable, safer, smaller, lighter, faster. Basically, engineers and scientists have always aspired to maximize efficiencies in weight, size, speed, convenience, and so on. However, now that algorithms, artificial intelligence and large data not only impact our possessions, but also increasingly affect our social lives and our inner feelings, efficiency might not be the ultimate aim for technology anymore. Big data, algorithms and other technological innovations have, and increasingly will have, more impact on who we will meet, what information we will access, what places we will visit and ultimately on how we will live our lives.

Think of how algorithms rule the social networks we use, hence suggesting us to interact with certain people rather than others, to add a person to our list of friends, to access certain news rather than others. Our social lives, our feelings and likes and dislikes are not regulated by the concepts of efficiency and improvements in technical terms. But it is not only about social networks; our relationship with our homes is changing, for example. Our smart homes observe us, they predict our needs and actively interact with us in many ways – including talking to us. Furthermore, our cars suggest us what ways to drive, what places to visit and so on. Engineers – or computer programmers – will have to question the value of efficiency over emotions, feelings, sensations, knowledge, relationships. For example, having more friends is not necessarily better than having less, and a sentimental relationship is, in many ways, inefficient; driving pass the house of our ex-lover might be convenient time-wise, but not emotion-wise; and turning on the vents in the kitchen while our mother bakes the apple cake like she used to when we were kids might make us miss the chance of recalling pleasant memories and emotions.

As the ones who invent and design the next algorithms and artificial intelligences, professionals coming from the technology and mathematical (STEM) worlds all of a sudden find themselves with an unprecedented responsibility – the one of shaping our personal and social lives. Their algorithms, their smart devices are now an integral part of our most intimate and emotional lives. Because of this new role of technology, we need those professionals to be able to reflect on aspects like ethics, feelings and human relationships. Moreover, we need them to critically think of the impact that their decisions have on what really makes us humans.

Besides our personal life, also other apparently scientific, technical or mathematical broader issues, such as global warming, finance, retirement policies, electoral laws, vaccination, etc… might need to be solved culturally, socially or anyway with a humanistic approach, rather than just scientifically. In fact, behind the parameters that control the afore-mentioned issued, which to some extent can be controlled by scientific discoveries and mathematical formulas, there are people with their beliefs, behaviours, feelings and relationships that need to be taken into account.

We are used to think of progressing scientifically and technologically and only later make ethical decisions. Nuclear engineers can equally work on solving power shortage or on future weapons; biotechnologists can help relieving hunger or feed the industry of patents over seeds. We live at a time where we cannot afford anymore keeping the science distanced from the humanistic discourse. Instead, we should put scientists and engineers at its very core and help them build their critical thinking and communication skills. This is when art comes into play.

6. The Criticality of Art

It is extremely difficult – if not impossible – to give a definition of what art is, and it may also not be necessary for this paper. However, the first author recalls having a great teacher, Dutch artist Barbara Visser, telling him what art should do. She said, good art should *"say something about the world"*, about what we desire and what we fear, and it should constantly question what is good and bad. A good artist has a critical eye and is subject to criticisms and analysis.

Art is, in all cases, a critical practice. Beyond the mere exploration of aesthetics and the production of art that manifests inner and intimal conditions of the author, artists are also given the role of manifesting their dissents and the dissent of their communities towards many aspects of our societies. For example, Chinese artist Ai Wei Wei is known for producing work the criticize the Chinese government and its censorship, thus being arrested and put in jail for almost 3 months in 2011 (Sorace, 2014). Similarly, Iranian film director Jafar Panahi's controversial movies about the restrictions placed upon women in Iran have so enraged Iranian authorities that Panahi has been arrested several times (Cheshire, 2012). Beyond political protests, art has also shaped the cultural and political response to the AIDS pandemics during the 1980s, with artists like Keith Haring, Niki de Saint Phalle or Robert Mapplethorpe raising their voice. Art is a great lens through which anyone can observe and act upon he world around us (McDonald & Wessner, 2003).

Working on an art project presents a great opportunity to provoke, raise questions and physically manifest reflection on our societies, cultures, economies, and ethics. Arts naturally create space for critical debate about our politics, ethics, economies, societies.

When we educate our students, whether engineers or artists, we know we are also preparing the next generation of global citizens, consumers, policy makers. Our concern is therefore not only to provide the students with all the tools and knowledge to find a job, but also we push them to train their critical thinking, their reflective mind and their individual will, so that wherever they will operate, they will be able to meaningful contribute to the discussion that surrounds them and not be mere executioners of someone else's agenda.

Furthermore, art also represents a unique way to look at the world, including the STEM world, and to challenge scientists to think further about their own practice and push the boundaries of their realms (Williams, 2017). Some artists have either made scientific discoveries or contributed to develop scientific knowledge. For example, in 1954 composer Lejaren Hiller has develop the first computer-made music contributing to the development of artificial intelligence (Roads, 1980); painter Abbott Thayer with his illustration book *Concealing-Coloration in the Animal Kingdom* has put the basis for theories on camouflage (Behrens, 2009); artist and art critic John Ruskin developed knowledge about tree growth (Ruskin, 1893); without mentioning the countless geometric patterns that artists generated thus making mathematical formulas visible (Jay, 2001), or the more recent developments in digital fabrication made by artists the likes of Joris Laarman (Figure 5)(Doubrovski, Verlinden, & Geraedts, 2011).

Figure 5 An impression of a 3d-printed bridge that artist and designer Joris Laarman's start-up company MX3D is planning to build in Amsterdam in 2018.

7. Five Things Art Can Do

It has often been discussed about the benefits that science could bring from opening its doors to artists and science. From the perspective of a scientist, the creative professional is someone that can embellish and make scientific knowledge more appealing and understandable. This is probably true, but there is much more to gain in educating our scientists and engineers in an artistic context, rather than simply involving creative professionals in scientific research. In the next paragraphs, we list five reasons why art would integrate well in a STEM model.

7.1. Art welcomes technical skills

It is true that there is a lot of art that is completely immaterial and purely conceptual. However, most art manifests itself physically or visually. Therefore, if one possesses technical skills; he or she is able to create. Whether his or her creations are three-dimensional machines, or virtual systems or chemical reactions, the person with technical skills has already the tools to express him or herself and to produce work. That is why it is reasonable to encourage computer programmers, engineers, scientists to dedicate some of their time to art projects. In contemporary art, there are many examples of artists who have a background in scientific subjects. Among them, we can think of Theo Jansen, who studied physics before becoming an artist (Jansen, 2007); movie director Alfred Hitchcock studied at the London County Council School of Engineering and Navigation (Taylor, 2013); and visionary architect Santiago Calatrava has a background in civil engineering (Tzonis & Rosselli, 1999), to mention a few.

7.2. Art encourages critical thinking

Once one knows that he or she can create, he or she will have to figure out what to create and why. What do I want to say? Why do I want to say that? These are the questions that resonate in the head of an artist before or while producing work. Such a phase in the creative process, forces the author to think critically about the world and build a personal opinion about it. This is a valuable reflective process that trains our critical thinking.

7.3. Art challenges know-how

Often, art pushes the boundaries of know-how and technologies beyond their conventional use. Once one starts working on an art project, and has figured the conceptual or critical messages to send out, it is very likely that he or she will need to tweak techniques, materials and processes in order to achieve the best results. The artwork therefore becomes the drive to experiment and make new discoveries. Painters of the past, for example, in order to achieve the results they had in mind had to develop perspective and colour theories, sculptors had to experiment with unusual materials and new production methods.

7.4. Art teaches you to take critiques

Art exposes you to criticisms, therefore it teaches you how to articulate and defend your reasoning. Art does not end with the exhibition or publication of a work, but it is exactly then that the discussion with others usually takes place. Teachers, visitors, readers, critics will praise and attack your work, you will have to explain what, how and why you sent certain messages. Some messages, you will not even be conscious about the fact that you sent them. You will learn a lot about your work and how others perceive it in this phase. Learning how to receive and respond to criticism is important as it prepares the students to face confrontation and manage a dialogue with others.

7.5. Art trains you as a person

Art provides you with the tools and context develop and express sensitivity towards emotions, feelings and sensations. This is something that engineers and scientists need to be more and more familiar with as the technological, scientific and mathematical discoveries have a greater impact on people's intimate lives.

8. Conclusions

If the engineering world is more concerned with HOW, while the arts focus more on WHY, something needs to be done. Both try to answer to an even more crucial question, the question of WHAT? What to do is the leading dilemma for creators – whether as engineers, scientists, designers or artists – and the two find very different answers to such a question.

WHAT to do is the common ground that scientists at broad and artists operate on. HOW and WHY are the two questions that we must learn not to separate in our schools, unless we want to train future professionals that either lack critical abilities or that lose touch with the reality of making and the possibilities offered by technologies whose potential we do not yet fully comprehend.

In other words, both science and humanities represent two lenses through which one can look at the world. Our culture and society have often preferred keeping those two lenses separated, rather than overlapping them. Thinking artistically allows space to investigate the humanistic side of projects. It allows reflecting on society and culture. Thinking technically means learning practical skills, reflecting on what technology offers and getting inspired by it.

In our schools and universities of the present and future, we should teach our students to understand the HOW and the WHY something needs to be done, and provide both types of answers. Our students and their educators need to learn about the processes and the networks that are generated by the art and the engineering directions and comprehend the values that lay behind both. In this way, we will produce fully-rounded individuals that can have an impact in the world that we all have to share.

We must not be afraid to advocate that students think of themselves as artists and allow them to think conceptually and learn how to use irony, speculative thinking and sense for aesthetics as part of their language. The benefits of such a contamination between arts and engineering, science and humanities would be numerous. On a higher-level, we would be educating a more complete citizen, who can value and appreciate both spheres. Our students would become technology experts who can better understand how the projects they work on contribute to the shaping of our culture and societies. Professionally, this will hopefully give them more opportunities in the companies that operate at the verge of technology and culture. Or, such an understanding will maybe push the graduates to start their own practices in such a space. Also, in terms of communication, our students would learn how to speak to technical and creative people, adopt – or create – a language that can be more easily understood by both audiences and that can be more appealing to the general public.

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About the Authors:

Giovanni Innella graduated in industrial design at Politecnico di Torino, in conceptual design at Design Academy Eindhoven, and with a PhD in design theory and critique at Northumbria University. Giovanni is an active designer, critic and curator, based in Tokyo. Currently, Giovanni is Assistant Professor at Advanced Institute of Industrial Technology.

Paul A. Rodgers is Professor of Design at Imagination, Lancaster University. He is also the Arts and Humanities Research Council Leadership Fellow for Design in the UK. He is a co-founder of the Design Disruption Group who strives for positive change in health and social care.