Approaching a Smart Materials Literacy

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Introduction

“The limits of my language mean the limits of my world.”

Ludwig Wittgenstein, Tractatus Logico-Philosophicus, 1921

Information technology is nowadays present in almost every aspect of human life. Similar to how this technology constantly influences our daily environment, behavior, society and culture, it has an immense impact on architecture and both the way space is designed and used. For architects to remain up-to-date with the latest technological developments and be progressive but sensitive in their spatial integration, their role and proficiency equally has to evolve and adapt. For architectural education this means to efficiently prepare students for upcoming eventualities and possibilities. On a theoretical level this involves the thorough analysis of contemporary tendencies, beliefs, and developments in terms of technology, ecology but also culture and society. Likewise it requires the practical training of skills and knowledge, such as the use of new tools, techniques, and materials. Most importantly however it demands preparing students with capabilities in interdisciplinary communication and exchange, which Nic Clear, head of architecture and landscape at the University of Greenwich, believes are essential to overcome the archaic idea of the architect representing the one and only master expert.¹

At the very basis of interdisciplinary progress is however not only a system of equal hierarchies and a shared curiosity in approaching a common goal but particularly the capacity of everyone involved to successfully communicate and converse. This necessity becomes even more obvious when areas outside the standard periphery of the architect are involved, such as materials science, biology, or chemistry, the birthplaces of many newly emerging materials. These domains are not only used to aesthetically very distinctive means of representation and the use of specialist language but for example also have a fundamentally different understanding of scale and durability. Hence for architects to successfully collaborate with these areas on the development of new, technology-enhanced spatial experiences they need an understanding of discipline-specific distinctions, a curiosity in scientific exploration and most of all be literate in a shared way of expression.
Smart Materials are Dynamic Materials

Every material is inherently dynamic and responds to external influences such as temperature, pressure or electricity by changing its volume, color or other physical properties. Yet albeit materials continuously change and behave, they do so largely in a non-human perceivable way. Smart materials however are fundamentally distinct from traditional materials since their response is much more immediate and can be tuned and controlled. Such materials can adjust their color in response to a rise or decrease in temperature or UV radiation, they can switch their transparency, light up, or move through electricity, they can store heat and energy, they can convert sunlight, heat or mechanical distortion into electrical power or even possess the ability to self-heal and repair. For the development of spatial solutions where adaptivity and interaction play a certain role such materials offer great possibilities and have various advantages over existing, mechanically complex systems. However, in order to treat smart materials as more than just a product, which replaces an existing technology one needs to understand their behavior over time and evaluate the range within which they perform. This requires expertise in their transformative abilities as well as a general idea of their internal processes and structure. One option to gain such knowledge is to reduce the materials into their individual parts, explore the functions of each of these parts, and then put them back together. An electroluminescent display for example consists of a transparent, conductive front electrode, a phosphor layer (which emits the light), a dielectric layer and a rear electrode. Through this DIY process one comprehends how the individual parts relate to each other and how changes in assembly result in particular material properties or behaviors, which then can be tailored to special demands or requirements that vary from commercially available products. At the core of this idea is not the education of a specific material expertise or the perfection of existing systems but more the mediation of a general know-how of certain principles, which help to communicate with specialists from the respective disciplines. Such exchange might then fuel the collaborative discovery of previously undiscovered applications or even incept the development of new materials.

One way to mediate such knowledge to students is through running explorative material workshops. In order to find an appropriate and interesting material one can start with a brief (online) search into new material discoveries or developments. This search can relate to certain
material phenomena such as color-change, movement, light-emittance, energy conversion etc. or focus on novelty and recent discoveries. Once a particular material has been found it needs to be evaluated in more detail, especially in relation to functionality, performance, potential deficiencies and limitations, and assembly, which can be done by studying scientific papers, technical articles, or other related information. When a basic theoretical understanding of the material has been acquired, scientists can be approached to provide more specific details. Albeit the knowledge one has prior to contacting an expert scientist might be limited it still provides a basis for further exchange and proofs an honest interest into the other’s work. The next stage involves acquiring the necessary ingredients and tools to build the material and breaking down the assembly procedure into distinctive steps. Once again expert support can help in finding the right sources and clarifying fabrication sequence. A particularly demanding part is to estimate the necessary quantities since often the ingredients are either expensive or only available in larger quantities. In some cases ready-made kits can be acquired, which allow for the manufacture of a certain set of prototypes and which usually come with detailed instructions. In other cases

Students exploring new materials at a workshop at the Dessau International Architecture Graduate School (2016).
the previously contacted scientists might have surplus that they’d be willing to share. As soon as all the required tools and substrates are at hand one can start making the first samples. What is important to remember is that failure and breakage are essential elements of the process and it might take a few attempts until a functioning result has been produced. Once one feels confident in building a working material, this knowledge can then form the basis for a student course or workshop, related to a certain topic or idea.

While this approach definitely makes for a lot of fun among workshop participants and provides them with useful techniques, which they can adapt to other materials it is impossible to go through such an intense process for every smart material available. Therefore a more general approach is required.

The Materiability Research Network:
Open Access to Smart Materials

Common ways for the communication of material knowledge include libraries, catalogs, and databases, both physical, in print, and online. Within such libraries, materials are usually sorted and categorized in respect to similarities and shared physical properties. In respect to static materials such types of categorization together with a two-dimensional representation through photographs and/or technical drawings is sufficient. Especially when having a little experience one can predict how a material feels or what it can be used for simply by looking at it or reading about its properties. Regarding smart materials however, which are far less known and available, it is much more difficult to anticipate their usage, especially when, as mentioned above, one aims at more than replacing something that already exists.

An attempt to make these materials more openly available is the materiability research network (www.materiability.com), a community platform, an educational network, and an open materials database that provides access to emerging material developments on various levels. The main intention of the network is to demystify smart materials and reveal their abilities while fostering inter-disciplinary exchange and cooperation. The website forms a constantly growing database on a broad range of materials, provides illustrated DIY tutorials to self-make them, and displays their usage in experimental projects or applications. The long-term goal of the network is to provide a community-driven, growing overview of smart materials in an architecture and design context, while encouraging its members to
exchange and critically reflect upon their potential usage, and foster the growth of interdisciplinary research and development.

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The hope is that through these two approaches, the direct physical experience of smart materials during associated workshops and the potentially unlimited access to similarly comprehensive information on the website, it will eventually become possible to anticipate the functionality, behavior, and usage of any type of smart material in a much more natural way, essentially approaching a smart materials literacy. This will finally detach smart materials from connotations to mechanically infused paradigms, which to date still mark the main form of describing dynamics, movement, and behavior. The herein presented approach as a didactic method has been tested and evaluated throughout countless workshops and student courses. Notwithstanding its shortness of a little more than five years it can so far be considered a largely successful model to engage students in exploring new territories, yet it obviously always needs to be adapted to the respective context and situation. Especially the architectural representation of dynamic behaviors still requires further investigation and needs the development of alternatives to established means such as plans and models.
As noted earlier the possibilities these materials offer for architecture are endless and could not only lead to dynamic and adaptive spaces but also to more efficient and much lighter, less material intense structures. Yet despite the functional advantages they have over existing systems their most important qualities are their emotive aspects and the more sublime impact they have on human senses. Engaging in possibilities and implications rather than the actual effects will hence become crucial to develop truly revolutionary products, spaces, or experiences.

Dr. Manuel Kretzer is an architect, researcher and educator. He is currently visiting professor at the Braunschweig University of Art, leading and teaching the subject ‘Digital Crafting’ and studio master at the Dessau International Architecture Graduate School. Manuel is the founder of the ‘materiability research network’, an educational platform that provides open access to cutting edge new material developments and technologies. He is also founding partner of ‘responsive design studio’ based in Cologne, a design office that works on various scales, including architecture, interior architecture, landscape architecture, furniture and object design. An overview of his work can be found at www.responsive-design.de, www.digitalcrafting.de and www.materiability.com.