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DRS LEARN X DESIGN 2019

insider knowledge

Fifth International Conference for
Design Education Researchers
9-12 July 2019
Middle East Technical University
Ankara, TURKEY

Editors
Naz A.G.Z. Börekçi
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The NautICS Materials Workshop: Teaching and Learning Interactive, Connected and Smart Materials for Yacht Design

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Abstract: Knowledge about materials is a key element in design education, considering not only their technical properties but also experiential and expressive-sensorial qualities of materials. To comply with this transition and with the emergence of novel materials, educators need to adapt or develop new formats, tools and methods for teaching and learning materials in design curricula. This paper presents a tentative design methodology experimented and validated in an educational workshop named *NautICS Materials*, with the aims of (i) teaching ICS Materials in the absence of material samples, (ii) exploiting the potential of ICS Materials in driving yacht design concepts; (iii) designing for ICS Materials; and (iv) introducing and applying the notion of materials experience. ICS Materials is an acronym that stands for Interactive, Connected, and Smart. Indeed, the domain of materials for design is changing under the influence of an increasingly technological advancement, which brings miniaturization of technology and material augmentation with the use of sensors, actuators, and microprocessors. Examples of new hybrid material systems with dynamic and computational qualities are increasingly emerging and raising the need to forecast their potentials in the design space and to reflect on their future application critically, both in design and in teaching. The workshop *NautICS Materials* -ICS Materials for the Nautical sector- is described by its objectives, structure, methodology, tools and results, in order to present a model to transfer to other sectors or to scale up in larger experimental and applied actions.

Keywords: *ICS Materials; materials experience; yacht design; design tools; design education*



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1 Introduction

Knowledge and skills about materials are fundamental elements in design practice and education. Conventionally, their contribution in the design space was limited to the selection of proper materials for integration into students' projects, contributing in the process of materialization. To do that, students were typically asked to acquire knowledge about material families, their technical properties, manufacturing processes, treatments and finishes, and – not least – their sensorial qualities. In fact, in the scope of design education, the role of the sensorial and experiential qualities of materials has remarkably increased. In the last 30 years, scholars and educators working in the area of materials for design moved their attention from the technical properties of materials to the expressive, sensorial, and experiential qualities of them (Manzini, 1986; Cornish, 1987; Ashby & Johnson, 2002; Rognoli, 2010; Karana, Pedgley & Rognoli, 2015). It is acknowledged that materials have qualities that go beyond the fulfilling of practical demands. They have intangible properties that captivate appreciation and that affect the experience of an artefact beyond its functional value. They are qualitative, non-technical, and intangible characteristics related to emotions, personality, and cultural meanings. These qualities of materials have been explored and classified by different scholars, constituting a substantial body of work identifiable as the notion of Materials Experience (Karana, Pedgley & Rognoli, 2013). Since materiality contributes to the definition of *product experience* (Desmet & Hekkert, 2017), the concept of materials experience arises as “the experience that people have through and with materials” (Karana, Pedgley & Rognoli, 2015), which is framed into sensorial, emotional, meaningful, and performative layers of experience (Giaccardi & Karana, 2015). The concept of Materials Experience grounds on a previous body of work, such as the Meanings of Materials (Karana, 2009) and the Expressive-Sensorial Dimension of Materials, i.e., the sensorial, subjective, qualitative, and unquantifiable profile of materials (Rognoli, 2004; 2010).

Because of this transition, traditional approaches and tools for materials teaching and learning in the design space are no longer adequate. Novel teaching and learning formats, tools, and methods have been inquired and developed to merge the duality of engineering-based and experience-based information in a consistent and complex frame that can be introduced to design students. The Expressive-Sensorial Atlas (Rognoli, 2004; 2010) supporting designers in their understanding of the material qualities and unfolding their relations with engineering properties and the sensorial evaluation scale (Karana, 2009) are two examples of these tools. These embrace a transition of educational approach from a theoretical one to a more explorative and practical one, integrating material education into design studios and experimental activities, such as workshops. In this respect, design students are enabled to design focusing on the appearance of materials, the feel and experience they induce, or start from a particular material and design meaningful applications for it, contributing to the development of materials and the identification of innovative solutions. This is evident in the application of Material Driven Design method (Karana et al., 2015) and Material Tinkering approach (Parisi, Rognoli & Sonneveld, 2017) in design studios, just to mention some examples.

One emerging challenge for materials education for design is the introduction of novel and unconventional classes of materials different from the traditional ones, such as Interactive, Connected, and Smart (ICS) Materials. The integration of these materials arises the need for new approaches, tools, methods, and formats for teaching and learning. In this scope, Materials Experience appears as a key notion for their understanding, conceptualization, and integration into a concept artefact.

1.1 ICS Materials

Novel materials with dynamic and interactive qualities, able to sense, process, and materialize data, are emerging under the influence of an increasingly technological advancement that fuels miniaturization of technology and material augmentation. These are explored by the basic research project ‘ICS Materials’ (Ferrara, et al., 2018; Bionda & Ratti, 2018; Parisi, et al., 2018 a; 2018 b), an acronym that stands for Interactive, Connected, and Smart Materials. Many of these materials are at their experimental and prototypical stage without a clear application. The practice of design has always facilitated the development and integration of novel materials (Ashby & Johnson, 2002). However, design practice and education lack a methodology to approach these materials. The purposes of the research are: (i) to develop methods and tools for design practitioners and students to understand, conceptualize, and design (with) them; (ii) to forecast their potentials in the design space, considering the role of the experiences enabled and implied by such materials; (iii) and to reflect on their future application critically. This paper is a step in this direction, by proposing a tentative methodology for material education for design, aimed to design with and for ICS Materials and describing its application and results in a Yacht Design educational workshop.

The definition of ICS Materials is here proposed as Hybrid Material Systems, i.e., material-based systems with different degrees of complexity combining inactive materials, smart material components, and embedded sensing, computing, and actuating technologies. Individual aspects of such materials have been explored and formalized by previous and

current researches of colleagues in the intersection of Design, Materials, and Human-Computer Interaction (Vallgård & Sokoler, 2010; Razaque, Dobson & Delaney, 2013; Barati, Giaccardi & Karana, 2018). They mainly perform shape-shifting, light-emitting, and colour-changing behaviours. The seamless combination of elements into a material system might enable less intrusive and more inclusive experiences, a more immediate and engaging interaction, and sustainable integration of technologies into everyday practices.

The research is positioned in the intersection of design, new materials, and interaction. We assume a *behaviouristic view* of Interaction (Saffer, 2009), which underpins a broad meaning of the term, by also considering other means of interaction different from digital and computational, and adopting an inclusive approach (Buchanan, 2001). Thus, we consider a broad range of materials empowered by computational, mechanical, chemical and biological components as sensors and actuators. ICS Materials arise as potential enablers of meaningful dynamic and interactive materials experiences as tangible interfaces for a diversity of applications, from interactive architecture to smart fashion, from autonomous vehicles to smart and conversational objects.

1.2 Emerging Trends in Yacht Design

With emerging technologies and cutting-edge materials, the yachting industry is evolving rapidly to meet the needs of modern yacht owners and is growing both on sales volume and boat size. The market, indeed, is continuously rising and since 2014 has benefited from the upward demand for yacht charter and water-based luxury experiences moving towards the large yacht segment (Boat International, 2018; Deloitte, 2018). Between 2010 and 2017, the 60 meters plus market segment, so-called *megayacht*, has grown by an average of 11% and with the perspective to reach US\$ 74.7 billion by 2022 (Global Industry Analysts Inc, 2017), confirming the theory that the high-end sector appears to be more resilient to any crisis in international markets (Campolongo, 2017). As yachts are evolving into superyachts and megayachts, the design projects are moving away from the traditional conservative nature of this industry with ergonomic-based use of space at the centre of design practice, to *luxury design* boats where a project is highly influenced by the client personality and aesthetic, and where the design criteria are revealed with [emphasized and special characters" (Celaschi et al., 2015). Designers are now experimenting with new soft features for higher sensory expressions, looking for new types of interaction between yacht, sea, and human behaviours. As introduced in The Future Yacht by Boat International (2017):

Lifestyle design is the new undercurrent of yachting, promoted by fellow disruptors who assert that most currently available yachts don't live the way today's new affluent society does. The disconnect is palpable. People want a vessel that will give them experiences they can't have elsewhere, and for too long have been handed designs for vessels that simply replicate all their land-based elsewhere, albeit with a pointy end. These are exciting times, yachting at the cusp of change.

Looking with the lens of experience design we can identify the following key elements as yacht design trends (Bionda & Ratti, 2018):

- **Experience the sea.** Soft features and flexible/convert spaces highlight the continuity between indoors and outdoors. Living areas themselves are evolving with the advancing glass and material technology. Material experience assumes an important meaning as it becomes a great catalyst of emotions able to throw the yacht owner into an augmented experience.
- **Innovative layouts.** The General Arrangement is moving away from traditional structures with divided interiors and smaller outdoor spaces. There is an increased focus on larger outdoor areas and lighter open plan interiors. The structural constraints are becoming less, leading to more interesting ways of designing spaces and combining areas with organic structures and pop-up spaces explored in several yacht design concept.
- **Focus on health & wellness.** Owners are looking to carry their balanced lifestyle into the world of yachting. The spa experience is accelerating: gyms, cryotherapy chambers, salt inhalation rooms, hot yoga studios are just a few of the ideas on the drawing board.

2 The NautICS Materials Workshop

Among the diverse potential areas of use of ICS Materials –from automotive to smart architecture, from the health sector to consumer electronics–, the Nautical transportation demonstrates to be one of the most suitable and competitive sectors of integration. Here, ICS Materials may be the enablers of meaningful experiences, expanding the unique interaction between the living space, the sea, and human behaviours. On this theme, a 3-day educational workshop named *NautICS Materials* was organized and run by the authors at Politecnico di Milano, Master in Yacht

Design program. The educational workshop involved 28 students with the goal to foresee and ideate future scenarios in the yachting sector, by conceptualizing new ICS materials and applying them in Future Yacht design concepts.

This workshop was designed to be adopted as a training program in a design firm or in the new yacht department of a shipyard, involving students with different backgrounds who had no knowledge of ICS material and materials experience. A specific set of activities framed in a tentative design methodology —namely *Design for ICS Materials*— with their supporting tools were developed: Yachting Scenario Boards, ICS Materials Cards, and a Concept Canvas. The workshop had the objective of experimenting and testing a tentative methodology to: (i) teach ICS Materials in the absence of material samples, (ii) exploit the potential of ICS Material in driving yacht design concepts, (iii) design for ICS Materials and (iv) introduce and apply the notion of Materials Experience.

2.1 Master in Yacht Design

The First-level Specializing Master in Yacht Design (MYD) at the Politecnico di Milano-POLI.design was founded to meet the strong demand for training in the pleasure-craft segment and provides the tools for managing the design and construction of sailing and motor boats, from project brief to definition of general plans, hydrostatic and hydrodynamic calculations, fitting-out of interiors, deck and board equipment, boat systems, production in the yard and control of executive stages. Students attending the programme have different backgrounds, both academic – architects, product designers, and engineers– and cultural.

NautICS Materials is a three-day educational workshop program designed as a first step in approaching ICS Material for a yacht design project, organized and run by the authors at MYD. As the workshop was conceptualized to be the first experience in design with ICS Materials, the 28 MYD students involved had no knowledge either about Interactive, Connected and Smart materials nor about material experience. Indeed, the teaching activity on materials offered in the Master program is conventionally limited to the technical proprieties, manufacturing processes and finishing of construction materials. The materials contribution to yacht design projects are restricted to a selection of materials, with their treatments and finishing integrated as a material board in students' works. Since previous didactic units on materials under a technical profile have already been provided to the Master students, this workshop aimed to introduce the notion of Materials Experience and apply it to designing with and for emerging and complex materials. The workshop was organized at the halfway of the Master learning path, when students have already developed yacht design skills in managing the shape and the general arrangement of a boat, as well as in construction material and system engineering. Regarding students' experiences in yacht design processes, the *NautICS Materials* workshop aimed to overturn the traditional way of designing a yacht, by exploiting the potential of ICS Material in driving the concept design of functional and aesthetic elements for future yachts, embedded in the interior layout of the vessel.

2.2 Workshop Methodology

The workshop methodology was designed by the authors to reach the intended workshop objective of (i) teaching ICS Materials in the absence of material samples, (ii) exploiting the potential of ICS Material in driving yacht design concepts; (iii) designing for ICS Materials; (iv) introducing and applying the notion of Materials Experience. The methodology of the *NautICS Materials* educational workshop could be adopted as a training program in Academia as well as in a design firm or in the new yacht department of a shipyard, as it is addressed to professionals with different backgrounds and no previous knowledge in materials experience or ICS Materials. To achieve its objectives, the workshop had three features:

- the students were divided into five multidisciplinary groups of at least five members to reflect a common yacht design studio;
- the work time period and tasks were split into sections to give a rhythm to the design activity, verify duration of tasks, and increase efficiency;
- a personalized toolkit was given to each team to drive the different design phases. The toolkit contained Yachting Scenarios Boards, ICS Materials Cards, and a Concept Canvas specially designed for the workshop (to know more, go to <http://www.icsmaterials.polimi.it/>);
- the students were asked to develop a yacht living area (whether in a sailing- or a motor-yacht) driven by the material experience and stimulated by a given scenario without pre-assigned vessel typology and size.

The workshop was organized in the following seven sections conducted for eight hours a day, with a one-hour lunch break, for three days:

Introduction and preparation [2 hours]: presentation of the macro-trend of the yachting sector and ICS Materials research by the tutors; division of the students into groups and toolkit distribution.

Exploration [2 hours]: opening of the toolkit and getting familiar with trends, ICS materials, and Yachting scenarios. Answering the question “what does the future hold for superyacht design?” to start thinking about how the next level of yachting would be like with new smart materials. Tools: Yachting Scenario Boards and ICS Materials Cards.

Definition [2 hours]: to narrow the area of intervention, selection of a part of a yacht journey (sailing, mooring/at anchor) or a part of the day and definition of an onboard space in which the concept project of the new material system will be developed. Tools: Yachting Scenario Boards and ICS Materials Cards.

Conceptualization [4 hours]: ideation of new material system concepts and visualization of yacht experiences enhanced by ICS materials, through sketches, mood boards, storyboards, and textual notes. Tools: Yachting Scenario Boards, ICS Materials Cards, and Concept Canvas.

Integration [4 hours]: integration of the material system concept ideas into feasible design proposals. Tools: Concept Canvas.

Design [8 hours]: development of Yacht concepts, using conventional design and representation tools and techniques, i.e. drawing and rendering by hand and software.

Delivering [2 hours]: exhibition and presentation of the final work to the other teams and open roundtable discussion. Outcomes: 3 posters (A2 landscape format) for each group.

2.3 Tools

2.3.1 Yachting Scenario Boards

Based on the first experiences of ICS_Materials research project, *Mapping ICS Materials Workshop 2017* (Parisi et al., 2018 b) and *ICS4YD Workshop 2017* (Bionda & Ratti, 2018), different case studies were divided into five groups, taking into consideration both the characteristics of each reactive and proactive materials and the sensory stimuli/information while sailing in a yacht. Then, the following five new scenarios for the yachting industry were finalized: *The Warty Jellyfish Mood*, *Moisture Poetry*, *Wave of Good Noise*, *Thermo-Taste*, and *Dynamic Equilibrium*. Each scenario was presented through an inspirational A4 board providing a mood board, an envisioning textual storytelling, and different keywords regarding the sensorial, emotional, interpretive, and performative layers of the proposed onboard experiences (Figures 1 and 2). This tool was used mainly in the exploration phase to drive the first design choices and to start envisioning how the next level of yachting would be like with new smart materials.



Figure 1. Thermo-Taste yachting scenario board - front.

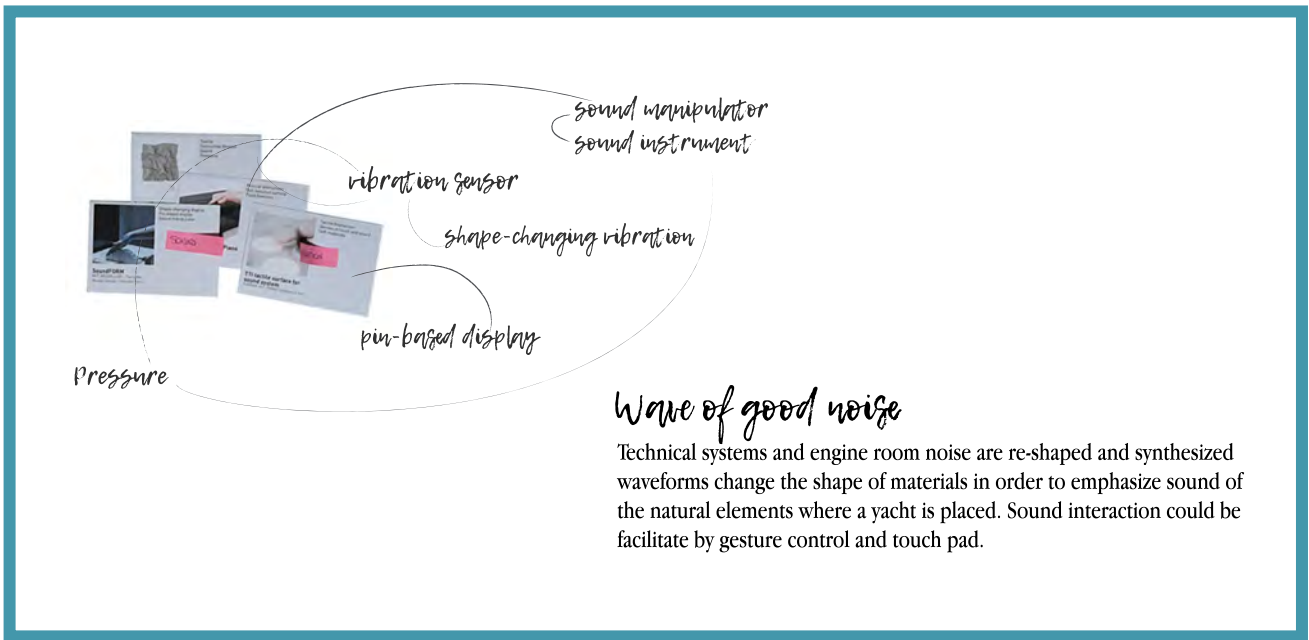


Figure 2. Thermo-Taste yachting scenario board - back.

2.3.2 ICS Material Cards

A deck of 48 cards was designed with the purpose of helping students understand all the elements of ICS Materials and build new concepts with them, by gaining an understanding of what they are, how they are made, how they work, and how they appear, and identifying their inputs and outputs of interaction. Each card shows an example of ICS Material, with pictures and textual information, i.e., name of the project, name of the author, a short text describing how it functions and performs, and a graphical schematic representation showing its components, inputs, and outputs (Figures 3 and 4). To do that each example was deconstructed into its constituting elements. The examples that have been selected by the authors to build the cards deck encompassed materials, surfaces, and material-based objects and systems used in many applications, with different behaviours, complexity, and technological readiness levels. In the Exploration stage, the students were asked to read the content of the cards, cluster them and select the most promising examples according to their scenario.

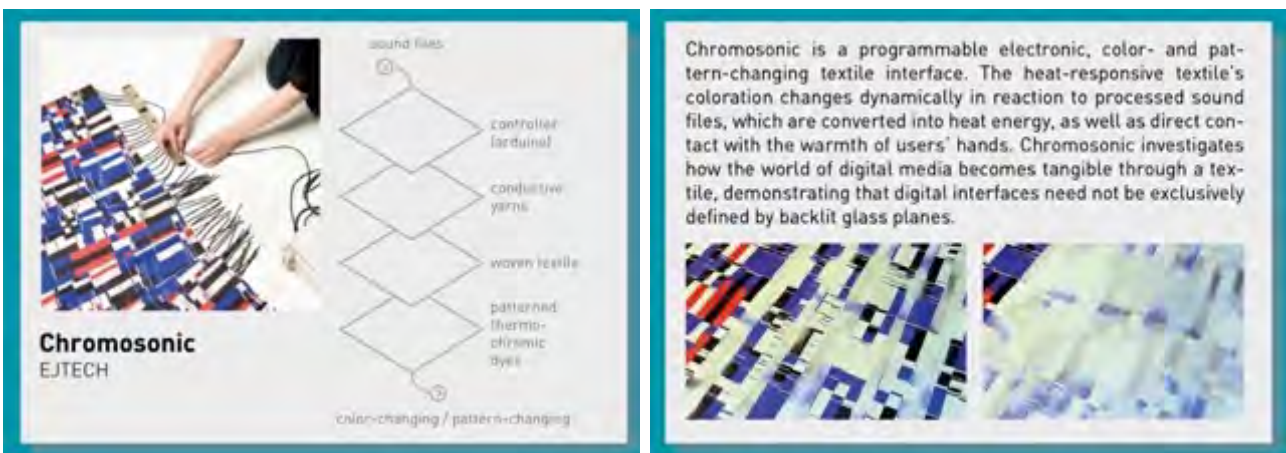


Figure 3. ICS Material Card of the case: Chromosonic by Ejtech (front and back).

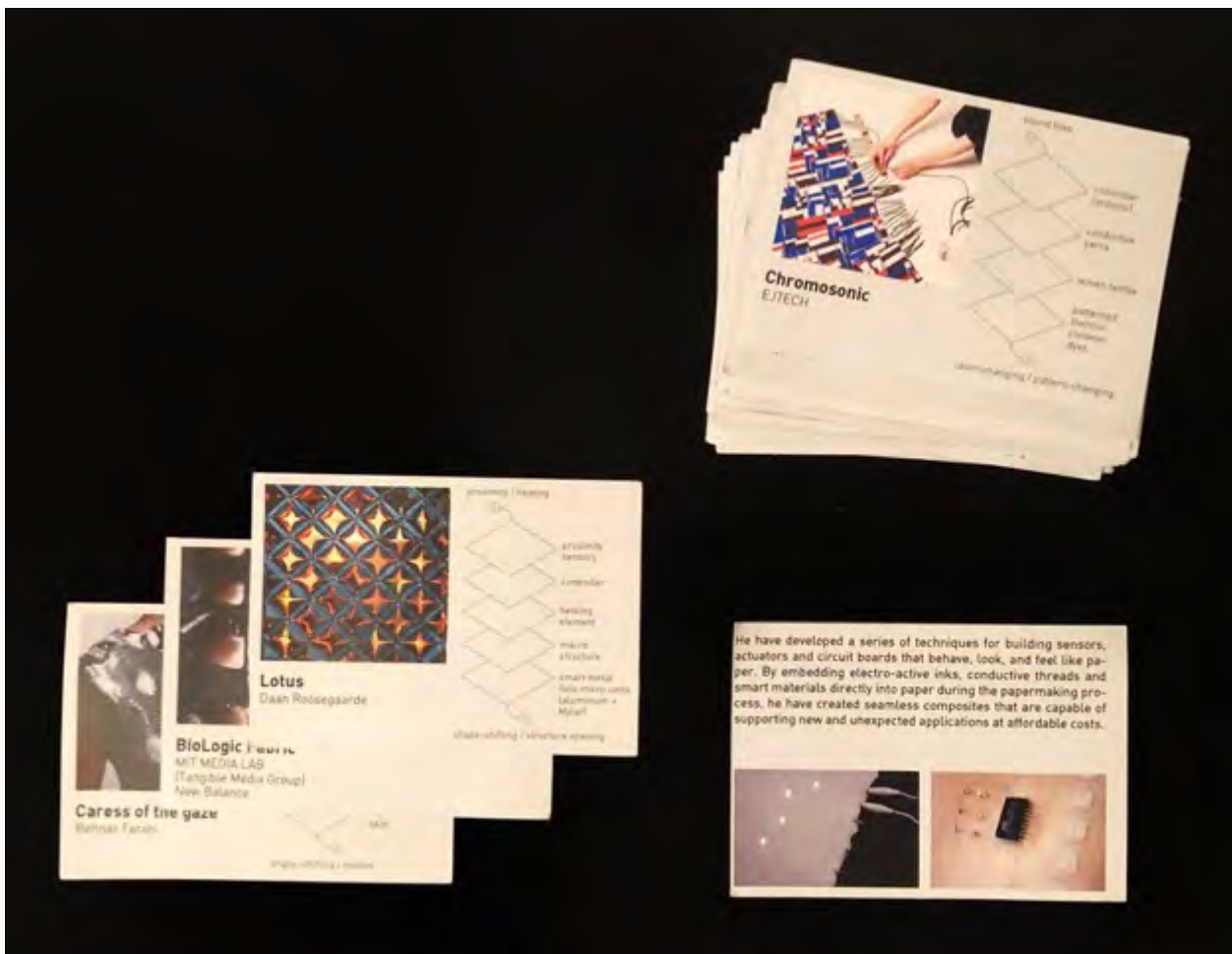


Figure 4. A selection of ICS Materials Cards.

2.3.3 Concept Canvas

A Concept Canvas in A3 size was designed to be used mainly in the conceptualization phase (Figure 5). The purpose of the canvas was to guide the students through the novel design methodology to conceptualize a new ICS Material (Figure 6). The canvas was divided into three sections, namely (i) material system building, (ii) material system sketching / picturing, and (iii) material system description. The first section provided an empty schematic graphical representation of a material system with blank spaces to be completed with the names of components, input, and output. This recalled the same design used in the cards. The purpose was to use the scheme to build a novel material system by getting inspirations from the examples showed in the ICS Materials Cards and combining their constituting elements in a new coherent design. Although the scheme represents a simplified laminate construction, other ways of integrating and combining elements in a composite structure may be considered. The second section provided a blank box where students could start materializing the first concept idea with sketches, collages of pictures, or mixed techniques. The third section asked to outline the concept with textual technical description (*how it works*), performative description (*what it does*), sensory and experiential description (*how it feels, looks, and sounds*), based on the Materials Experience framework (Giaccardi & Karana, 2017). This last section aimed to reflect upon the performances and experiences enabled and implied by the concept, based on the individual material components and the composition of them in an articulated system. Even though we suggested to follow the steps sequentially, the three activities could be carried out in parallel with an iterative approach, as each section inform the others.



Figure 5. ICS Material Concept Canvas.

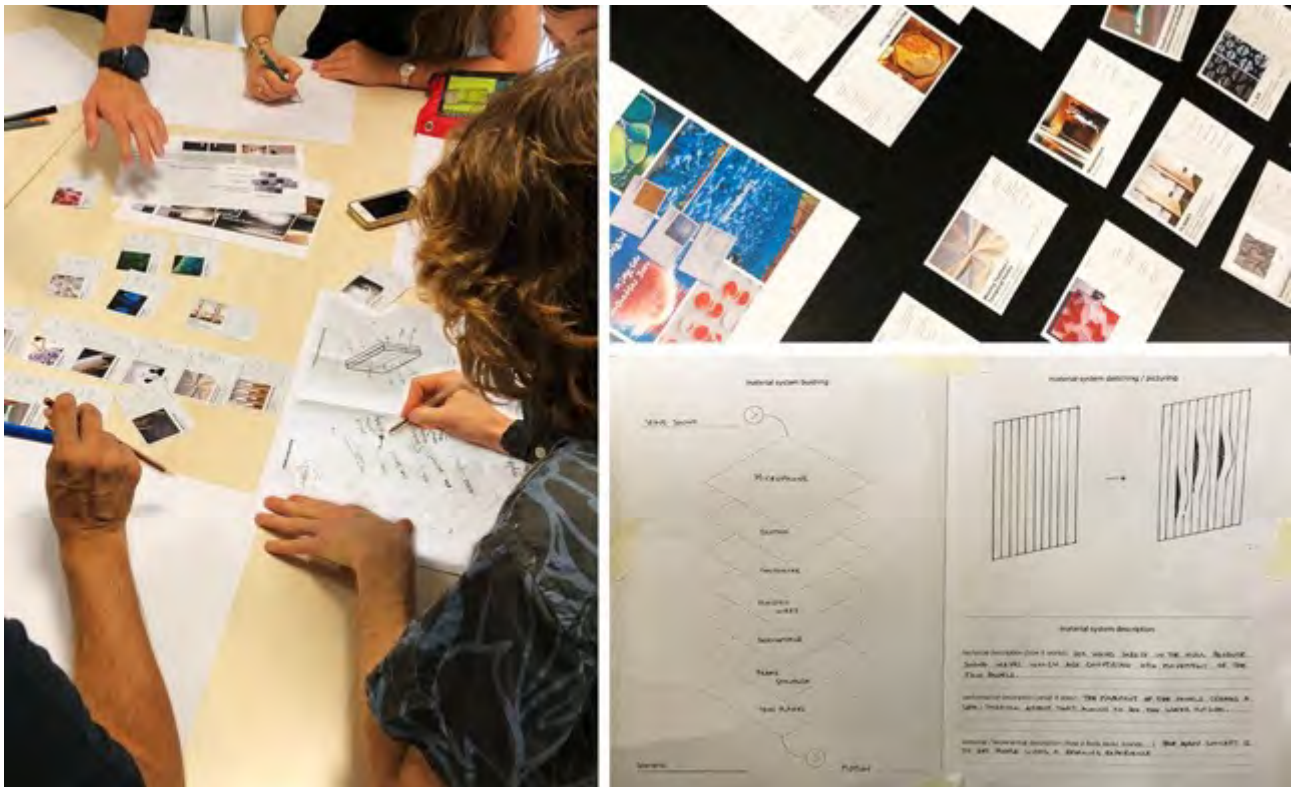


Figure 6. Activities and intermediate stages of the NautICS Materials workshop.

3 Results

During the *NautICS Materials* workshop activity, students conceptualized novel material systems, through the recombination of depicted components, and fully integrated them into the design concepts of functional and aesthetic elements embedded in the interior layout of the vessel. As tangible interfaces, they materialize external and imperceptible environmental data, so that humans could experience them through augmented expressions. Changing their characteristics on external stimuli, ICS Materials influence the aesthetics and perception of spaces, encouraging sensory experiences while sailing or mooring. Five resulting design concepts related to Future Yacht driven by the ICS Material experience are described below.

The sailing yacht concept *Glowrious* (Figures 7 and 8), based on *The Warty Jellyfish Mood*, re-images the relationship between the on-board natural and artificial light transforming the yacht hull into a luminescent night illusion system, by embedding photo-luminescent pigments into a smart glass controlled through Arduino. The smart windows catch the external light coming from the sun, by absorbing it with photo-luminescent pigments located on the glass surface, and reflect it on the water. A LCD panel is located between the internal and external glass to provide an electrochromic effect. The electrochromic glass gives the freedom to control the interior light intensity from both daylight as well as the photoluminescent elements. The sensorial experience is a *bioluminescent plankton effect*, a diffuse light wrapping the yacht hull. Inside, the warm and pleasant light refracted from the water with different intensities gives an extrasensory experience during mooring and sailing.

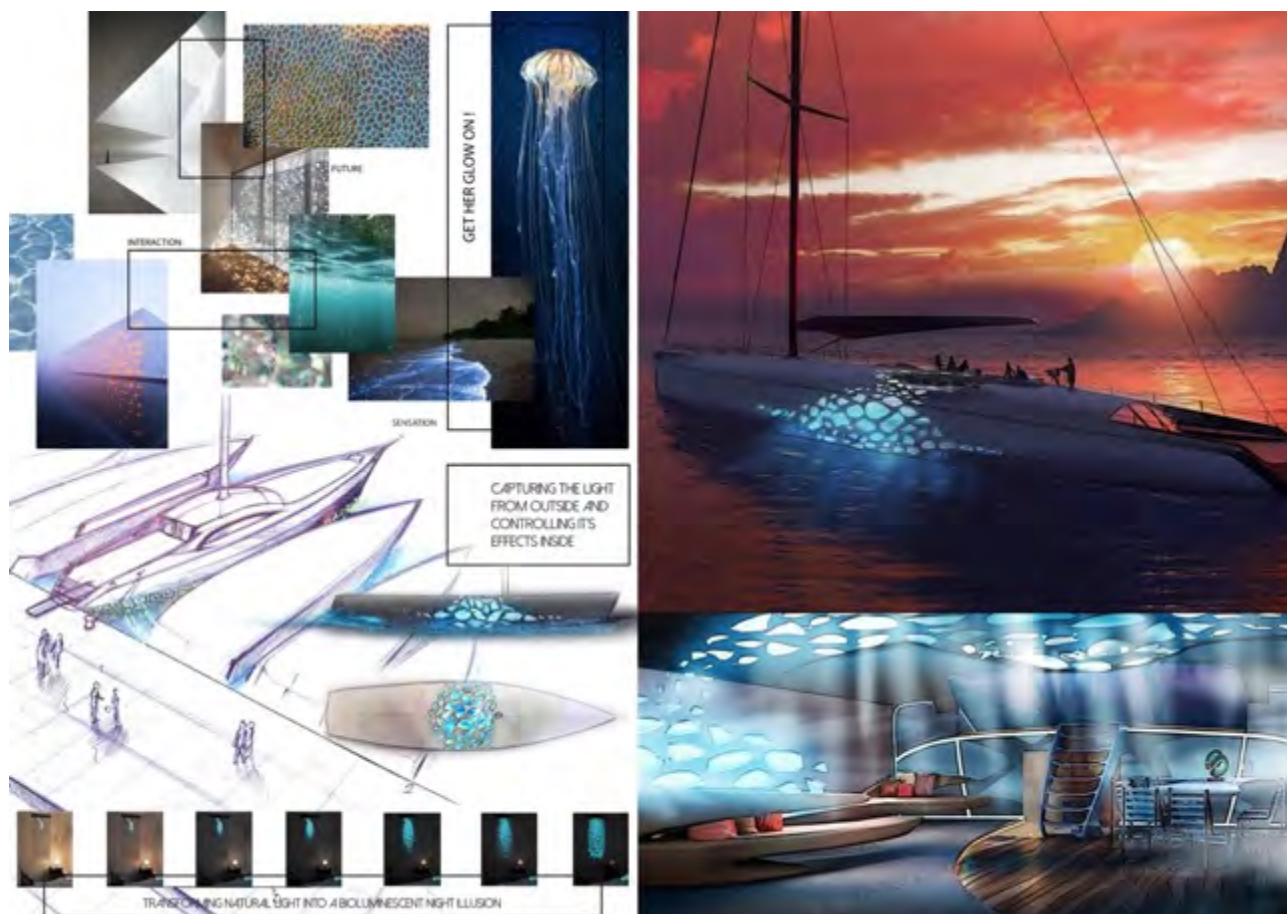


Figure 7. Glowrious yacht concept.

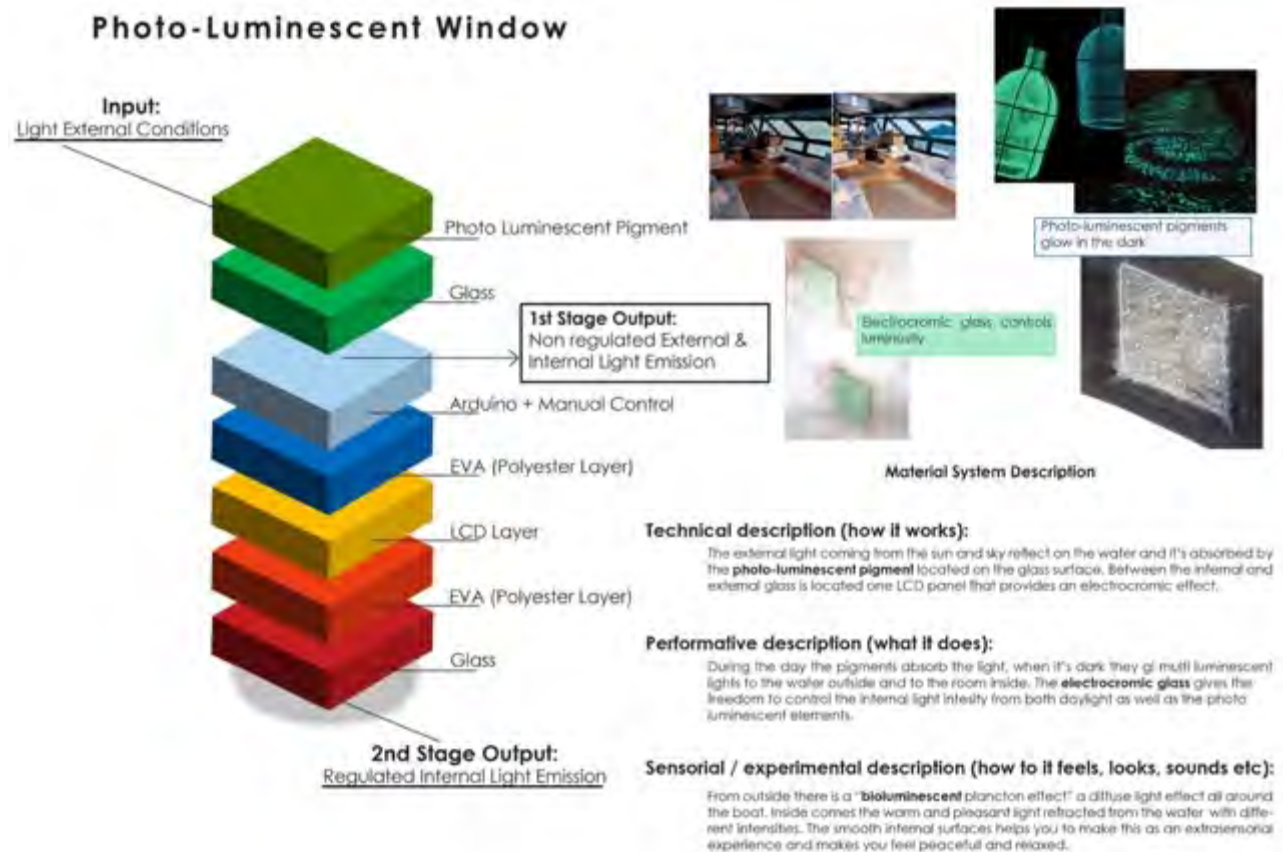


Figure 8. Glorious' smart windows material's graphical schematic representation: components, input and output, and description of the materials experience it enables.

The Floating Forest, developed from the *Moisture Poetry* yachting scenario, uses inboard moisture to create a futuristic biosphere providing onboard water and light through a twofold hybrid material system. The first ICS Material developed has the primary objective of transforming the excess moisture inside the biosphere to drinkable water and is composed of four layers: a hygrometer sensor, activated absorbent, porous plate, and a hydrophobic slider. The second material is a light emitting one that takes moisture concentration in living spaces as input. This material is made out of five different layers, which also act as a structural component of the vessel: a hygrometer sensor, an absorber sponge to collect the moisture of the space, a porous aluminium foil as a capillary, a hydrophobic slider and hydrochromic pigment to produce light.

Taking the inspiration from the *Wave of Good Noise* scenario, Dynamic Flow materializes the wave sound frequencies in an interior waterfall thanks to external sound sensors. The sound of waves is reproduced in a visual effect through a complex system made out of an external microphone for short-range sound waves, a microcontroller, a tune generating software and the electrical and water system that provide energy and water to the interior waterfall.

The Underwater Breathing Nest is based on the *Thermo-Taste* yachting scenario and reinterprets the yacht interior as a living creature able to react to the human presence and heat, creating comfortable areas through shape-shifting smart textiles covering the interior surfaces. Heat sensor work together to identify human presence and temperature through proximity. Once detected, the information is transferred to the electrosensitive layers that react expanding themselves like a living creature. The interior effect is a boat breathing from the gills enriched with a dynamically controlled comfort temperature.

The last concept developed was Heckquilibrium inspired by the *Dynamic Equilibrium* yachting scenario. Through light, it shows the effect of wind and water forces on a sailing boat, enveloping the interior with movable plywood panels covered with light-emitting smart textiles and optic fibres responding to pressure sensors. When the vessel is stable, the panels are closed giving a simple cladding effect. However, when the boat heels the panels open up, offering a dynamic experience by following the angle of the heeling hull. Moreover, dynamic textile patterns added to the plywood panels react to rough sea emitting light according to the wave pressures. From a technical point of view, a nano pressure sensor located along the length of the hull measures heeling angle and water pressure. The signal is

received by a control unit that controls independently both the panels' servo motors and the light emitting optic fibres on each panel.

4 Discussion

At the end of the workshop, students were asked, by means of a questionnaire, for their feedback in order to measure the effectiveness and reception of the activity. The *NautICS Materials* workshop confirmed the effectiveness of the tentative methodology in achieving the objectives. All the students, with no previous knowledge on ICS Materials and materials experience, were able to conceptualize novel material systems with different degrees of complexity combining inactive materials and smart material components. The toolkit proved its potential in guiding the design phases from the material understanding, to the new materials conceptualization, and their integration into yacht design concepts. The cards overcame the limitations caused by the lack of physical samples of the actual materials and provided immediate and effective information on the materials. However, future development of the methodology may integrate material samples and prototyping. Both students and tutors realized that time-wise a 3-day workshop is too limited for the development of innovative design concepts that could integrate a mix of aesthetic, functional, material and typological innovation. Indeed, just two of five concepts revealed significant implication of the material development into innovative yacht shapes and functions. In most cases, the yacht concepts were disconnected or not influenced by the material that have been conceptualized, resembling conventional yachts especially on the outside. However, taking inspiration from another industrial sector, the design concepts implemented a new generation of material for composite structure, exterior and interior design and sails with dynamic, augmented, and proactive properties. The notion of Materials Experience has been learnt and applied by students, providing inspiration and details to the concepts. The visionary and speculative approach implied by the theme of Future Yacht and ICS Materials have been appreciated by students and requested to be integrated in other didact units of the Master in Yacht Design. Furthermore, the workshop proved the potential of ICS Materials to influence the yacht spaces perception enhancing the onboard experience: as tangible and material interfaces, they materialize external and imperceptible data enabling multi-sensory and engaging yachting experience and allowing the user to be more proactive and engaged in their interaction with spaces and the navigation. To foster and exploit the potential of ICS Materials, future application of the methodology in a design workshop could direct such materials to create awareness, alleviate, or contribute in solving today's environmental problems. Just to mention some examples of potential directions in the Yacht sector, ICS Materials may visualize environmental information to create awareness on the quality of air, help in the filtration and depuration of polluted water while sailing, or be used as an alternative and sustainable source of energy-harvesting for self-sufficient boats. Furthermore, future workshops could address the design of new ICS materials from natural sources or with a low impact in production, such as second row materials or DIY materials.

5 Conclusion

The paper drafted the main theoretical foundations about the research *ICS Materials* in relation to material education for design and depicted the educational workshop *NautICS Materials* by its objectives, structure, methodology, tools, and results, in order to present a model to transfer to other sectors or to scale up in larger experimental and applied actions –not only in education, but also in practice with industrial partners– for the integration of smart materials and technologies in the design space. Taking into consideration the outcomes and inferences from the pilot application in the Yacht Design sector, the methodology could be applied and extended to other fields, including, but not limited to, transportation and automotive, health, smart, micro and/or temporary architecture, mobile space suite, consumer electronics, and smart and conversational objects.

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