



## EDITORIAL

# Engineering Grand Challenges Demand for Trans-Disciplinary Design Science

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The 21<sup>st</sup> century society has to face global problems of unprecedented scope and scale that challenge traditional human approaches and solutions. The overexploitation of natural resources demands profound changes of mentality in the development of future artefacts, but the current economic paradigm still pushes towards innovations expected to be successful in a short-term perspective, whatever their impact is for future generations. Large parts of the scientific community are indeed struggling for a radical shift of goals and attitudes, as for instance the proposal of Engineering Grand Challenges raised by the National Academy of Engineering (Vest, 2008).

In this context, overcoming the traditional borders of scientific disciplines appears as an essential step: “*Convergence of the life sciences with fields including physical, chemical, mathematical, computational, engineering, and social sciences is a key strategy to tackle complex challenges and achieve new and innovative solutions*” (Committee on Key Challenge Areas for Convergence and Health *et al.*, 2014).

Nevertheless, there is an evident lack of educational reference practices suitable to enhance the development of trans-disciplinary skills and competences.

As remarked also in the editorials of the last issues, this journal aims at contributing to the scientific debate in this context by favouring the presentation of respectable opinions of scholars through position papers, and by publishing research findings that allow to develop knowledge advancements on trans-disciplinary design principles, processes and techniques.

This issue offers both types of contribution: the first position paper by Raymond Yeh proposes stimulating reflections about ethical aspects of technological innovation and on the profile of competences and sensibility innovators should have. “*College graduates must have both cents and sensibility*”, where “cents” represent the required skills and competences of today’s, but also of future’s jobs; while “sensibility” provides the capability to “*find the proper balance to navigate between today’s necessities and long term aspirations in life*”.

The new generations of *Trans-disciplinarians* should go beyond the current technocratic dogma, with a holistic view on potential consequences of today’s decisions also on a long-term perspective, yet fulfilling the real needs and expectations of human being (D’Anna & Cascini, 2016).

In this perspective, 21<sup>st</sup> century universities have to create *meaning makers* and not “only” solution makers. We hope that those insights will foster the discussion in next issues of this journal.

The second position paper by Oscar Garcia highlights the change of mindset and background necessary to exploit the potential of quantum information and computing. As discussed in the paper, the roadmap from basic research to engineering applications of quantum theory presents many critical problems to

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address and traditional engineering curricula do not provide adequate competences to address them efficiently. Besides proposing an exemplary semester course on quantum information and computing to fill this gap, Garcia stimulates a change of perspective to motivate studies in this field, by taking into consideration the “potential applications of the engineering quantum marvels”, rather than focusing only on the basic questions to answer.

The other two papers present complementary research outcomes that still contribute to the development of a trans-disciplinary design and process science. Specifically, Liang-Xing Su et al. discuss the concept of interface beyond the perspective of user interface. The ambitious goal of the authors is to build a theoretical framework for the design of a generalized interface suitable to address “*the interactive relations among humans, artefacts, nature, and societies*”, thus aligned with the holistic perspective of the evolution of engineering design. As a first step, they propose a literature review of studies about interfaces in physics, computer science and industrial design. The discussion stemmed by this review will constitute the ground level for the further development of generalized interface design.

Jihoon Kim and co-authors, in the second research paper, dig the potential of crowdsourcing for designing complex engineering systems. This appears as a critical issue for addressing with adequate thinking resources the engineering challenges of the next future. While the expected advantages of crowdsourcing are well known in terms of enhanced creativity of collective thinking and reduced costs of large-scale outsourcing, less evident are the potential limitations when dealing with complex systems. In fact, in this case, crowdsourcing could bring to disconnected pieces of information, not necessarily adequate in quality and suffering of feasibility issues due to technical and social aspects of parcelled idea generation. The paper proposes a formal model, based on Actor Network Theory, to study the optimal characteristics of a crowdsourced design team. The case of Quirky.com illustrates the logic and the expected benefits of the model.

In line with the general aims and scopes of this journal, the Editorial board welcomes the submission of further papers that contribute to the development of a theoretical foundation and related methods and tools suitable to address 21<sup>st</sup> Century Grand Challenges, and among the others, the specific questions approached in the papers of this issue.

## References

- Committee on Key Challenge Areas for Convergence and Health, Board on Life Sciences, Division on Earth and Life Studies, & National Research Council. (2014). *Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond*: National Academies Press. doi: <http://dx.doi.org/10.17226/18722>.
- D'Anna, W. & Cascini, G. (2016). Adding Quality of Life to Design for Eco-Efficiency. *Journal of Cleaner Production*, 112, Part 4, 3211-3221. doi: <http://dx.doi.org/10.1016/j.jclepro.2015.09.109>
- Vest, C. (2008). Context and Challenge for Twenty-First Century Engineering Education. *Journal of Engineering education*, 97(3), 235-236.

## Author Biography

**Dr. Gaetano Cascini** holds a Ph.D. in Machine Design and is Full Professor at Politecnico di Milano. His research interests cover Design Methods and Tools with a focus on the concept generation stages both for product and process innovation. He is member of the Advisory Board of the Design Society and co-chairs its Design Creativity SIG. He has coordinated several research projects, among the others the European Project Marie Curie-IAPP FORMAT (FORecast and Roadmapping for MANufacturing Technologies). Currently he is the coordinator of the European projects: SPARK: Spatial Augmented Reality as a Key for co-creativity (Horizon 2020 – ICT) and OIPEC: Open innovation Platform for university-Enterprise Collaboration: new product, business and human capital development (Erasmus+ – Capacity Building in Higher Education). He has authored more than 140 papers presented at International Conferences and published in authoritative Journals and 13 patents.