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EDITORIAL

Inspiring the future change-makers: reflections and ways forward from the Challenge-Based Innovation experiment

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Since 2013, CERN IdeaSquare has issued thousands of "licenses to dream" to students, faculties, and stakeholders engaged in Challenge Based Innovation (CBI) inspired programs (CBI-like) together with universities and institutions willing to inspire future change-makers to tackle global challenges.

CBI-like programs are educational projects where university students, PhDs, and MBA fellows work in multidisciplinary teams to solve innovation challenges while applying Design Thinking principles (Kurikka et al., 2016). Teaching the design thinking process includes implementing user-centered activities, building prototypes to test hypotheses, collaborating in multidisciplinary teams, and developing project-based teaching structures (Dym et al., 2005). The CBI-like programs widened the Design Thinking approach by incorporating additional elements such as international collaboration (Jensen et al., 2018), distributed collaboration (Kurikka and Utriainen, 2014), translation of fundamental research into societal applications (Kurikka et al., 2016), open innovation, and collaboration with companies and organizations.

The initial motivation to establish IdeaSquare and to create CBI-like programs was to translate fundamental research into societal applications (Kurikka et al., 2016). In CBI-like programs, teams are inspired by technological ideas from instrumentation development or basic research at CERN, one of the world's leading research centers in particle physics, to creating disruptive innovation for societal impact in the context of the United Nations Sustainable Development Goals. For this reason, in terms of innovation processes, all the CBI-like programs are designed to lie at the intersection among open science and open innovation. This makes IdeaSquare a platform where scholars experiment and exchange best practices around the fuzzy front-end phase of innovation. Over the years, scholars have used CBI-like programs to experiment with different innovation, teaching, and design methodologies (Dell'Era and Landoni, 2014). This work resulted in 21 publications (7 Journal papers, 14 Conference papers), two reports, and 7+ Master Theses summarised in Table 1.

Tab 1. CBI-inspired programs literature review.

Year	Papers
2014	(Kurikka and Utriainen, 2014)
2015	(Bortesi, 2015; Buzzaccaro, 2015; Gerstenberg *et al.*, 2015; Heliövaara, 2015; Kriesi *et al.*, 2015; Manetti, 2015; Utriainen, 2015)
2016	(Hassi *et al.*, 2016; Kalasniemi, 2016; Kriesi *et al.*, 2016; Kurikka *et al.*, 2016)
2017	(Benvenuti *et al.*, 2017; Kurikka, 2017a, 2017b; Masini, 2017; Mincolelli, 2017; Utriainen and Taajamaa, 2017; Utriainen, 2017)
2018	(Charosky, Hassi, *et al.*, 2018; Charosky, Leveratto, *et al.*, 2018; Jensen *et al.*, 2018)
2019	(CERN Ideasquare, 2019; Faria and Fernandes, 2019; Palomäki, 2019; Pisoni *et al.*, 2019)
2020	(Copy *et al.*, 2020; Gallagher and Savage, 2020; Pisoni *et al.*, 2020; Teo, 2020)

This special issue was inspired by these eight years of experimentation, leading to six papers that focus on three main topics: (1) learning from experimenting with CBI (Ojasalo and Kaartti, 2021; Papageorgiou et al., 2021), (2) experimenting with deep tech in innovation processes (Balboni et al., 2021; Thong et al., 2021), and (3) impact and future of CBI experimentations (Colombari et al., 2021; Colombelli et al., 2021).

Universities and higher education institutions are well aware of the changes needed in their programs to educate students for a more creative, innovative, and entrepreneurial society, moving away from a lecture-centered approach and towards a more student-centered constructivist approach (O'Connor, 2020; Schmitz et al., 2017). CBI was conceived as a laboratory for universities to experiment with new pedagogies and approaches, where CERN involvement is a major attraction for students and academics, and the IdeaSquare open platform welcomes innovation projects and collaboration activity. This unique setting was used by many universities to prototype the courses of the future.

Papageorgiou, Hassi, Bragos, Charosky, Leveratto, and Ramos-Castro (2021), in their article *'Prototyping the future of learning: reflections after seven iterations of Challenge Based Innovation (2014-2020)'* present the

reflections on seven years of experimentation on CBI Fusion Point, a 12-credit course offered by a collaboration of three universities in Barcelona: Esade (business), UPC (technology) and IED (design). Using qualitative research grounded in ethnography, the presented results of the reflection on pedagogy and innovation are at the nexus of experiential learning, design thinking, and challenge-driven education. The authors present organizational implications as well as tested solutions for universities wishing to implement CBI-like course, such as the importance of an ecosystem architect to manage a vast network of collaborators, a flexible space and time project workspace moving away from campus-focused models; a flexible course planning model in terms of hours and content to adapt to emerging needs of the projects and faculty upskilling to better coach as students' partners and co-learner.

Ojasalo and Kaartti (2021), in their article *'Fostering learning with challenge-based innovation in higher education: case CERN Bootcamp'* present a case study on designing and implementing a CBI course for learning service design by solving societal challenges related to United Nations Sustainable Development Goals coordinated by Laurea University of Applied Sciences in partnership with CERN IdeaSquare, Haaga-Helia University of Applied Sciences, Metropolia University of Applied Sciences, and the University of Helsinki HIP Helsinki Institute of Physics. Their work highlights how CBI enhances Significant Learning dimensions, indicating that students also learn general skills critical to their development as citizens. In CBI, students learn to *"interact with other people, acquire and apply knowledge, combine theory and practice, understand and develop solutions for global and societal wicked problems, work constructively under time pressure, and communicate with various methods and audiences"* (Ojasalo and Kaartti, 2021, p. 19). The CBI experience led the authors to reflect on the critical issues for organizers and instructors. that should pay attention to give enough scaffolding to the process without compromising flexibility while enabling serendipity in the learning environment that is ensuring a fun and multidisciplinary students' experience.

The link between Open Science and Open Innovation lies in the capability to transfer the value of deep technologies, such as the ones developed at CERN, to society (Cheah and Ho, 2021). After several years of experimenting with deep tech in open innovation processes in CBI-like processes, academic researchers produced tools and practices to address the deep tech to societal value gap. The Open Innovation teams can now use specific methods that extend the general user-centered design approach to accelerate deep tech adoption.

Balboni, Dosi, Marchini, Mincolelli, and Vignoli (2021), in their paper *'N2T 'Need to Tech discovery' tool: enabling interaction with scientists in CBI students' project'* present a design tool that embeds technological and scientific inputs into human-centered design processes. The design tool supports a structured search that identifies a situated list of technologies with their potential value for the solution concepts. N2T works in two steps. It starts by revealing the connection between user needs and technology-independent functionalities through a divergence map. Then it leverages tech functional scenarios to support the interactions with scientists to identify potentially valuable technologies. The experimentation of this tool happened in OPER.CBI involving the Universities of Bologna, Modena and Reggio Emilia and Ferrara. The authors designed N2T as a "translator" among science and innovation, generating robust results in the design opportunity phase.

Thong, Cotoranu, Down, Kohler, and Batista (2021) present a case study on a process that translates deep technology into applications in their paper *'Design innovation integrating deep technology, societal needs, radical innovation, and future thinking: a case study of the CBI A^3 program'*. The authors present the development of a specific design innovation process in two phases with the creation and test of specific tools as *CERN Technology cards* and *Morphological charts* to integrate deep technologies, *Opportunity cards,* and *Ideation workshops* to address societal needs, *License to dream* and *Diegetic Prototyping* to integrate Radical Innovation and *2030 Future Canvas* and *Implementation Roadmap* to integrate Design for the Future. At the end of the program, students were able to acquire different competencies within and across domains, confirming the relevance of the CBI A^3 approach developed by Design Factory Melbourne at Swinburne University in partnership with inno.space at Hochschule Mannheim, New York City Design Factory at Pace University and Porto Design Factory at Politéchnico do Porto.

The application of CBI-like programs has increased over the years from three higher education institutions in 2013-14 to fourteen in 2020-21. The demand for programs fostering student transversal competencies, knowledge of sociotechnical problems, and collaboration with industry and community actors is increasing (Gallagher and Savage, 2020), and CBI has proven to be a laboratory to develop the University of the future. This requires an engaged faculty interested in leveraging the pedagogic innovation challenges offered by this context and developing new teaching and course organizational practices. Even during the COVID-19 pandemic, all CBI-like programs were offered, providing opportunities to learn about the possibilities of online experiential learning activities.

Colombari, D'Amico, and Paolucci (2021), in their article *'Can challenge-based learning be effective online? A case study using experiential learning theory'* leveraged a CBI-like course transition to digital in a COVID-19 scenario to assess the impact of online experiential education on learning outcomes and educational processes. Using Kolb's experiential learning model, the authors show that a digital transition

of CBI-like courses is possible and effective, identifying four main success factors. CBI-like program designers should design specific practices to support informal interaction, give more time for exploration, leverage the power of asynchronous lecturing for theoretical knowledge, and make challenges relevant for the students regarding concreteness and foreseeable impact. In this case, the CBI-like learning experience could be among the most effective and motivating ones in a virtual environment.

Colombelli, Panelli, and Paolucci (2021), in their article *'The implications of entrepreneurship education on the careers of PhDs: evidence from the challenge based learning approach',* were interested in the effects on the academic and business outcomes of involving Ph.D. students in entrepreneurial and innovative education programs. Comparing the performance of 73 Ph.D. who attended Innovation for Change (I4C), a CBI-like program offered by Collège des Ingénieurs, CERN IdeaSquare, and the Politecnico di Torino, with 73 who did not, they showed that the program had an impact on academic performance in terms of number and quality of publications for the PhDs who attended the course. The main explaining factor seems to be the researchers' change of mindset, which widens their ability to understand problems from multiple perspectives.

The papers presented in this special issue have multiple implications for Universities wishing to innovate their offering to respond to new and pressing societal challenges; for policymakers that have the responsibility to promote more impactful open science and open innovation activities; for researchers interested in improving and fostering challenge-based innovation programs to improve our planet; and for all designers involved in the fuzzy front-end phase of innovation.

CERN IdeaSquare and CBI-like programs are an open laboratory for everyone wishing to experiment with the future.

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