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Fablabs, makerspaces, and design spaces

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Design activities may be highly influenced by the environments in which they take place, and by the equipment provided in those environments, where the spaces may be both physical and virtual. The space can be influential because it provides the right ambience, or it facilitates experimentation, communication, and shared-working. It may be important in the ideas it stimulates or because it provides a location for reflection and contemplation.

This special issue of *AI EDAM* is devoted to papers on design workspaces and their role as drivers for creative and innovative behavior and outputs. Fablabs, makerspaces, and other design workspaces have been of particular interest for many years in design education, and their value is seen as increasingly important in industrial and research contexts.

Seven papers are compiled in this special issue. These original research studies report on the design and operation of design workspaces, virtual and experimental spaces, their users and usage patterns, their effect on collaboration, and their utilization by underrepresented user groups. They are original research studies of design workspaces in operation and of the design of experimental spaces and facilities.

The first paper in this compilation, "Spatial design factors associated with creative work: a systematic literature review", by Katja Thoring, Roland M. Mueller, Pieter Desmet, and Petra Badke-Schaub provides an overview of state-of-the-art research on design spaces within the academic, practice, and other innovative environments. By systematically analyzing relevant sources on creative spaces – 51 academic and 22 nonacademic – this study reveals the types of theoretical and practical contributions and the spatial constructs studied, their relation to creative workspace aspects, and the possibilities of new technologies to directly improve creative workspaces or to further support related research efforts. As such, this comprehensive overview enables a better understanding of the wider research field and indicates many potential avenues for further research. This literature review establishes the theoretical foundation upon which various other makerspace and design space studies can be categorized in terms of the type of theoretical contribution. According to Thoring et al. (2020), many recent developments with this research field have been based heavily on descriptive and analytical *interpretative* studies which serve as a starting point for higher-level theories like *causal* and *space design* theories, as may be seen in the following three articles.

Based on a descriptive study of facilitating user research through makerspaces, the second paper, "User research enabled by makerspaces: bringing functionality to classical experience prototypes", by Matilde Bisballe Jensen and Martin Steinert, presents four case studies of supporting fuzzy front-end design activities by providing access to makerspace facilities. It compares these makerspace-supported user research activities with traditional ones and demonstrates how they can allow broader experimentation with functional user experiences. The third paper, "What difference does an academic makerspace make? A case study on the effect and outreach of DTU Skylab", by Ali Özkil, Lasse Skovgaard Jensen, and Camilla Hansen, provides an in-depth study of usage patterns of an academic makerspace. By analyzing multiple data sources such as workshop registration forms, surveys, and reports, the authors present their findings related to the involved users, the usage of makerspace facilities, the effects of having makerspace on teaching and learning activities, and the satisfaction level associated with different makerspace elements. As such, the presented study indicates the main drivers for its successful implementation and reflects on educational benefits that it offers. The fourth paper, "What's taking so long? A collaborative method of collecting designers' insight into what factors increase design effort levels in projects", by Alexander Holliman, Avril Thomson, Abigail Hird, and Nicky Wilson, describes the Collaborative Factor Identification for Design Effort (CoFIDE) Method that can be used for identification, analysis, and estimation of effort levels in hackathon, makerspace, and design teams. The proposed effort estimation method relies on the perception of design team members, facilitating the identification of underlying influential factors to mitigate their negative impact on the successful project performance. The usability of the method is validated and demonstrated through a case study conducted in a UK-based product design agency.

In addition to these studies which cover both wider design space aspects and address some of the individual spatial characteristics, this special issue also includes two papers that tackle societal issues: engagement of women in makerspaces and makerspaces for humanitarian use. The narrowed research scope of these two contributions allowed a deeper investigation of associated societal constructs, emphasizing the contextual specificities needed for theoretical and practical improvements of a creative and collaborative makerspace environment. The first

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paper, "Academic makerspaces as a 'design journey': developing a learning model for how women students tap into their 'toolbox of design'", by Megan Tomko, Wendy Newstetter, Melissa W. Alemán, Robert L. Nagel, and Julie Linsey, examines the learning experiences of women in academic makerspaces and tries to address the challenges they face as a part of their engagement within that environment. Through a series of interviews with 20 undergraduate women students and analysis of their narratives, the authors uncovered recurring themes and proposed a model of learning in makerspaces. The learning model integrates different types of learning mechanisms and proficiencies, and clearly represents their interrelations and further impacts, with implications being transferable and adaptable even to different demographic backgrounds. The next paper, by Lucia Corsini and James Moultrie, titled "Humanitarian makerspaces in crisis-affected communities", tackles issues of crisis-affected populations through a potential usage of humanitarian makerspaces. This study thoroughly explains the phenomenon of humanitarian makerspaces, explores their role in supporting design activities, and provides practical implications of introducing these spaces, which support and empower people to develop required solutions that meet their own needs. By analyzing three humanitarian makerspaces, the authors explore enablers, challenges, limitations, and the impact they have on various beneficiaries within the European context.

The final paper in this special issue extends the definition of design workspaces over traditional boundaries to virtual spaces and environments that may serve for the conceptualization, analysis, and evaluation of digital prototypes throughout the design process. With the recent developments of virtual reality (VR) and augmented reality (AR) technology, their usage becomes more common for various traditional design activities such as reviews. Within that context, Andrew Wodehouse, Brian Loudon, and Lewis Urquhart, in the paper "The configuration and experience mapping of an accessible VR environment for effective design reviews", developed a new VR environment and interface configuration, "the Control Carousel", which provides users with easily accessible control and viewing of a digital model. By employing an experience-mapping procedure, the authors refined and further improved the proposed VR environment and associated configuration by focusing on different person–person and person–technology interactions. Finally, the newly designed environment has been validated in three commercial design reviews that were part of live projects across a range of sectors and product types.

In the past few years, the number of fablabs, makerspaces, and design workspaces opened by universities, public institutions, and private companies has been exploding. As demonstrated by the papers in this special issue, the topic has also been growing as a research field, with many research questions that are yet to be answered. On the other hand, it should be also noted that this special issue has been prepared for publication in the midst of the Covid-19 pandemic, which changed the definition of work and education for billions of people around the globe. As the societies re-open, we have adopted new norms for organizing the way we operate – and it is normal to expect that design workspaces, just like all other workspaces, will be affected from this breakpoint and the new norms that come with it. We believe that in the next few years, it will be very interesting to observe how makerspaces will evolve themselves and will be affected by these new norms and changes.

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