Digital Twins for Haptic Design Thinking: Application within CoDEMO 5.0

Alexander Voelz[1,*], Iulia Vaidian[2] and Christian Muck[3]

[1]*University of Vienna, Faculty of Computer Science, Doctoral School Computer Science, Währinger Straße 29, 1090 Vienna, Austria*

[2]*OMiLAB@University of Vienna, Faculty of Computer Science, Währinger Straße 29, 1090 Vienna, Austria*

[3]*OMiLAB NPO, Faulmanngasse 4, 1040 Vienna, Austria*

Abstract

There is a need for enterprises to transition from a technology-driven Industry 4.0 paradigm towards more sustainable frameworks that are based on the Society 5.0 concept, emphasizing green and human-centric approaches. The CoDEMO 5.0 project addresses the lack of personnel equipped with the necessary skills to facilitate this transition. As a result, the goal is to develop innovative training and collaboration frameworks by building upon the principle of co-creation among stakeholders with diverse backgrounds and interests. Haptic Design Thinking methodologies, and more specifically, the notion of Digital Twins for Haptic Design Thinking, are introduced as prospective input to support the project objectives. Building upon this notion, CoDEMO 5.0 aims to enhance the co-creative capabilities of decision-makers, thereby contributing to the broader agenda of establishing a workforce skilled for steering organizations towards sustainable, resilient, and human-centric development in the European context.

Keywords

CoDEMO 5.0, Haptic Design Thinking, Digital Twins for Design Thinking, Co-Creation, Society 5.0

1. Introduction

The development of more sustainable and human-centric approaches marks a crucial driver for the strategic alignment of today's enterprises. In response, the term *Society 5.0* was established in literature as overarching concept aggregating the progress of resulting approaches. This new paradigm focuses on the principles of sustainability, resilience, and human-centricity to guide the transformation of organizations [1]. The EU-funded research project CoDEMO 5.0 aims to facilitate the advancement of these principles by establishing suitable training and collaboration frameworks. As an underlying vision, CoDEMO 5.0 sets out to educate the upcoming generation of decision-makers to not only leverage the latest technological innovations but also account for the integration of sustainable and human-centric development principles.

An important aspect for the design of corresponding frameworks is the promotion of co-creative capabilities that enable collaboration among stakeholders from various domains. More-over, the essence of haptic Design Thinking, with its emphasis on expressing and visualizing

✉ alexander.voelz@univie.ac.at (A. Voelz); iulia.vaidian@omilab.org (I. Vaidian); christian.muck@omilab.org (C. Muck)

🆔 0000-0003-4580-1445 (A. Voelz); 0000-0003-3641-4072 (I. Vaidian); 0000-0002-2654-1070 (C. Muck)

complex ideas, plays a crucial role in promoting co-creation. To support these aspects, the notion of Digital Twins for Haptic Design Thinking is employed, which involves the process of transforming haptic results from physical workshops into digital, conceptual modeling-based representations that can be further processed, enhanced, and shared.

The goal of this work is to highlight selected objectives of the CoDEMO 5.0 research project and how Digital Twins for Haptic Design Thinking can contribute to achieving them. Following this goal, the theoretical foundations are laid out in Section 2, encompassing haptic Design Thinking methodologies, the notion of their Digital Twins, and Society 5.0. In Section 3, the context and current results of the ongoing research project are introduced before the contribution of Digital Twins for Haptic Design Thinking is mapped to the respective project objectives. Section 4 concludes this work by briefly recapitulating the most relevant arguments.

2. Theoretical Foundations

The theoretical foundations relevant to understanding the presented research project are explained below. This includes haptic Design Thinking, Digital Twins which are based on haptic Design Thinking workshops, and Society 5.0.

2.1. Haptic Design Thinking

The widespread use of Design Thinking in various domains and for various purposes has led to the emergence of numerous methodologies. A summary of most commonly employed Design Thinking methods is presented in [2], which is the reason for omitting detailed elaborations of the individual approaches within this work. At the core of each method lies a human-centered approach that aims to develop innovative solutions for existing challenges [3]. In today's interdisciplinary projects going along with digital transformation, such approaches are often utilized to bring together stakeholders with different backgrounds and, therefore, different interests for the purpose of fostering communication as well as collaboration among them [4]. In particular, physical workshops emphasizing tangible, hands-on materials like sticky notes and paper figures are gaining popularity within Design Thinking methods. The tangible nature of such haptic materials fosters a comprehensive understanding among participants, who often come from varied domains with different expertise [5]. In corresponding physical workshops, haptic tools can thus help the different actors externalize their domain-specific knowledge. The variety of physical representations created during these workshops capture a collective intelligence, a shared understanding that emerges from the synergy of diverse perspectives [6].

2.2. Scene2Model and Digital Twins for Haptic Design Thinking

In the context of haptic Design Thinking workshops, there persists a need for the documentation of physical representations resulting from them. Addressing this need, the ADOxx-based Scene2Model tool[1] offers mechanisms that enable the transformation of tangible outputs from these workshops into digital and machine-processable conceptual models [7]. This tool is specifically designed to capture the essence of haptic Design Thinking workshops, where storyboards

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[1]Available at: https://scene2model.omilab.org/

created with SAP Scenes[2] serve as foundational elements. The automated transformation of storyboards is facilitated by converting the individual paper figures of each scene into conceptual representations that can be modified upon demand within the adaptive modeling environment of Scene2Model [8]. Thereby, the domain-specific knowledge externalized by participants in haptic Design Thinking workshops (cf. Section 2.1) is captured in a computer-processable form that can be utilized for further processing, analysis, and sharing.

The various perspectives regarding the definition of the Digital Twin concept have been emphasized in related works [2, 9, 10, 11], and shall thus not be discussed to the full extent here. In these contributions, it is consistently argued that the notion of Digital Twins can be applied beyond production-focused interpretations to also cover non-tangible assets represented by interconnected, machine-processable models. Supporting this notion, a Digital Twin of a system has been defined by attributing three main elements: (i) models that represent the respective system under study, (ii) data traces from this system, including their aggregated or abstracted forms, and (iii) services designed to utilize the first two elements in a manner relevant to the represented system [12]. Building on this definition, the use of Scene2Model enables comparable elements: (i) representing scenarios from Design Thinking workshops as conceptual models, (ii) containing semantic data traces encoded in the form of haptic paper figures, while (iii) offering services for semantic enhancement and automated sharing for feedback generation [2, 13]. Consequently, it has been argued that Scene2Model transforms the domain-specific knowledge that workshop participants encode in co-created scenarios into what we label as *Digital Twins for Haptic Design Thinking* [10, 11].

2.3. Society 5.0 and related concepts

Society 5.0 represents a new paradigm initiated in 2016 by the Japanese Government through the vision of a *"society that is guided by scientific and technological innovation that will bring wealth to the people"*. This notion builds upon the evolution of society, from hunter-gatherer, agrarian, industrial, information up to super-smart [14]. It aims to revolutionize society as we know it by moving toward *human-centered* approaches. Hence, various sectors, organizations, and also technologies are impacted, which is often discussed in the context of Industry 5.0 [15]. Consequently, the skills and capabilities required from future leaders and decision-makers are also changing [16], as they need, among other aspects, to lead and sustain the merger between digital and physical space, as foreseen by Society 5.0 [14]. To answer the need for re-skilling and up-skilling decision-makers, the term *5.0 Organization* is introduced, which focuses on combining cross-sectorial and human-centered competencies with the technological potential of machines and intelligent systems in an organizational setting. It encompasses three dimensions: resilient, green, and human-oriented. The development of corresponding skills can be effectively supported by constructivist learning theories that provide a foundational framework on how learners actively construct knowledge through interaction with and social negotiations within their environment [17, 18]. Thus, constructivist learning methods, like Design Thinking [19], offer a human-centered approach to teaching cross-sectorial competencies required in modern decision-making environments, such as the subsequently discussed CoDEMO 5.0 project.

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[2]A storyboard consists of several scenes that are created by participants during physical workshops using haptic paper figures (cf. https://apphaus.sap.com/resource/scenes).

3. Co-Creative Decision-Makers for 5.0 Organizations

The nature of collaboration and co-creation has evolved significantly from historical practices to modern applications [20]. Today, advancements in technology and a shift towards customer empowerment are pushing not only companies but also city administration and other institutions to include stakeholders more directly in the innovation process [20, 21]. The CoDEMO 5.0 research project builds upon these principles, thus acknowledging the value of co-creation.

3.1. The CoDEMO 5.0 research project context

CoDEMO 5.0 (Co-Creative Decision-Makers for 5.0 Organizations)[3] seeks to boost European innovation by promoting the transition of organizations from Industry 4.0 to Society 5.0-inspired frameworks [22]. The principles of this new paradigm are utilized to support organizations from the healthcare, industry, and agri-food sectors by emphasizing sustainability, resilience, and human-centricity over the technology-driven focus of Industry 4.0. On this basis, CoDEMO 5.0 aims at fostering co-creation among socio-economic stakeholders, while also developing the necessary knowledge, skills, and competencies for cross-sectorial decision-makers. The project's main objectives and expected outputs are organized into four key streams:

1. *Value Co-Creation Labs* (VCC Labs): Establishing physical laboratory installations based on the Digital Innovation Environment of OMiLAB [23] that are enhanced with resources to support multi-stakeholder collaboration across six national networks of VCC Labs in France, Italy, Romania, Poland, Germany, and Spain; the aim is to foster development of 5.0 initiatives between socio-economic partners at the European level.
2. *Innovation Boosters and Catalyzers*: Developing a knowledge-sharing platform dedicated to boosting collaboration and co-creation among project partners and further socio-economic actors, with a focus on catalyzing innovation by leveraging the VCC Labs to capture Knowledge, Skills, and Competencies (KSC) for the 5.0 Certification process.
3. *5.0 Certification*: Offering a unique European Open Badge Certification for academic students and vocational trainees interested in acquiring 5.0 competencies that focus on green practices, resilience, and human-centric factors.
4. *Educational and Vocational Training*: Designing the learning content for certification and KSC development collaboratively by involving Higher Education Institutions (HEIs), Vocational Educational and Training (VET) partners, and industry partners providing practical case studies to foster constructivist learning approaches.

This initiative is pursued by a consortium of 13 international partners from six countries representing South, Central, and Eastern Europe, including HEIs, VETs, NGOs, and industry partners spanning three economic sectors. Additionally, associated partners from Austria, Poland, and South Korea contribute to and benefit from the project's outcomes, further expanding the value co-creation network. CoDEMO 5.0 is co-funded by the European Commission through the Erasmus+ program from October 2023 to September 2026 and coordinated by Mines Saint-Etienne in France under the leadership of Prof. Dr. Xavier Boucher.

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[3]An overview of the project approach, the conducted research, and produced outputs are documented on the project web page: https://codemo-project.eu/

3.2. Preliminary research questions and current project results

The objectives of the CoDEMO 5.0 research project emphasize the development of skills and competencies for decision-makers that guide the identification of needs and requirements relevant to the transition towards 5.0 Organizations. On this basis, the following preliminary research questions can be derived within the scope of the contribution at hand:

> **RQ 1:** *What are the key requirements of socio-economic entities transitioning towards 5.0 Organization frameworks?*
>
> **RQ 2:** *How can haptic Design Thinking workshops enhance the competencies of decision-makers for 5.0 Organizations?*

In order to answer the foundational RQ1, the project kicked off by conducting a two-part survey to assess the competence needs of future-oriented organizations and to understand the impact of 5.0 transformation in three sectors: industry, agri-food, and healthcare. The survey was conducted over a month and directed to HEIs, VETs, representatives of project partners, and other socio-economic actors. The results are currently being evaluated. However, from preliminary assessments, the KSC requirements can be categorized into four dimensions: resilience-oriented (refers to the ability to successfully adapt to adverse situations), digital-oriented (interacting and working with interconnected networks of humans-machines), green-oriented (linked to circular and green economy), and human-centered (driven by critical thinking and adaptive learning). The insights gathered by the survey form the foundation for building a generic framework for 5.0 competencies and deriving learning approaches, educational materials, and training modules. In this context, the contribution of haptic Design Thinking workshops to enhancing these competencies (cf. RQ2) has to be assessed, for which corresponding elaborations are presented in the following section. Future works beyond the scope of this contribution will have to determine in collaboration with industry partners which concrete resources are needed to support and evaluate the proposed framework in a laboratory setting, and whether it can be effectively generalized to other sectors beyond the CoDEMO 5.0 focus areas.

3.3. Contributing to the CoDEMO 5.0 objectives through Digital Twins for Haptic Design Thinking

Considering the overall objectives of CoDEMO 5.0 and the preliminary assessment of KSC requirement dimensions, several opportunities arise on how haptic Design Thinking workshops, and more specifically, Digital Twins for Haptic Design Thinking (cf. Section 2.2), can serve as a valuable contribution to answer RQ2. In particular, the support of multi-stakeholder collaboration in the context of establishing VCC Labs and the catalyzing of innovation in a co-creative as well as human-centric manner are promising opportunities.

First, the utilization of haptic Design Thinking workshops has proven to enhance communication and collaboration among stakeholders from various fields (cf. Section 2.1). In this context, the principles of co-creation [20, 21], collective intelligence [6], and human-centricity[4] form essential components. Applied together within constructivist learning approaches, they

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[4]The synonymous use of related terms (e.g. *citizen-centric*, *user-centric*) was discussed in recent works [13].
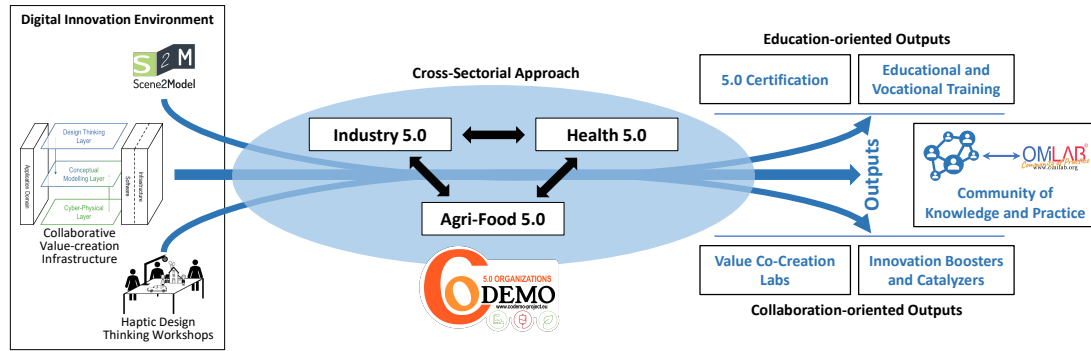
Figure 1: Contribution of Digital Twins for Haptic Design Thinking to the CoDEMO 5.0 project (based on the approach overview from the project web page[3])

enable diverse groups to collaboratively externalize their knowledge with the goal of fostering improved problem-solving, decision-making, and innovation [19].

Second, the notion of Digital Twins for Haptic Design Thinking, operationalized through the Scene2Model tool, provides an automated mechanism to capture the collective intelligence of diverse stakeholders collaborating in the co-creative and human-centric context of physical workshops. As solutions are commonly refined subsequent to workshops, corresponding representations can be enhanced and iteratively adapted within the Scene2Model environment, thereby offering a flexible way to track changes and progress.

In summary, the notion of Digital Twins for Haptic Design Thinking aligns well with the objectives of the CoDEMO 5.0 research project. More precisely, the approach of utilizing Scene2Model-supported haptic Design Thinking workshops within the aforementioned Digital Innovation Environment of OMiLAB [23] can serve as valuable input for the cross-sectorial approach of CoDEMO 5.0, as visualized in Figure 1. Following this approach, the industry partners will engage in dedicated workshops to explore the challenges of transitioning to a 5.0 Organisation and also identify suitable solutions tailored to each sector's needs. During the workshops, socio-economic collaboration and co-creative innovation design are enabled while accounting for the digital-oriented and human-centered KSC dimensions. Corresponding outputs have the prospect of building a foundation for both collaboration-oriented and education-oriented objectives. Moreover, the interaction of established VCC Labs through the OMiLAB Community of Practice [11] can foster long-term value co-creation in a growing network.

4. Conclusion

A human-centered society driven by data, information, and knowledge, also relies on collaboration to facilitate value co-creation. In this work, the CoDEMO 5.0 research project is presented as a forward-thinking approach to innovation and value creation, with haptic Design Thinking workshops as a method to foster interaction among diverse stakeholders. The workshop results and the knowledge encoded in them can be transformed into digital representations through the use of Scene2Model, thereby facilitating the principles of 5.0 Organization. Through its initiatives, CoDEMO 5.0 puts an emphasis on co-creation and collaboration while aiming to

contribute to the broader objectives of sustainable and technological development in Europe.

The paradigm of Society 5.0-inspired organizations requires further research into the emerging opportunities and challenges. The CoDEMO 5.0 project contributes to this direction and aims to support organizations' transition towards strategies that are not only technologically advanced but also sustainable, resilient, and human-centered. Reflecting on the foundational research question of the MIT Center for Collective Intelligence[5], CoDEMO's efforts correspond to the broader vision of accelerating human and technological capabilities by utilizing the strengths of individuals, communities, and digital systems to achieve a collective intelligence that creates more value than any single entity or technology.

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