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THE BOUNDARIES OF INDUSTRY-ACADEMIA INTERACTIONS: FIRST STEPS TO PREPARE IA-DESIGN EDUCATION FOR SOCIETY 5.0

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ABSTRACT
This article explores the integration of digital and physical assets in Society 5.0, emphasising the role of design and AI education in addressing societal challenges through technological innovation. It advocates for an agile action research approach in design education to equip students with practical skills for real-world challenges, aligning with global trends in human-centric design. The research methodology involves a collaborative effort among 20 academics, industry professionals, and students, and in this paper, we are analysing data from two workshops. The workshops focused on understanding integration models between industry and academia. This study used qualitative analysis and tools like Python's Matplotlib and NetworkX libraries to examine the workshop deliverables. It is predicated on the idea that transformative industry-academia collaborations will be essential in Society 5.0, requiring a synergy of theoretical research and practical applications. It underscores overcoming bureaucratic and trust barriers to create sustainable, impactful collaborations. Our outcome so far is that the success of industry-academia partnerships depends on the following key factors: alignment of values, effective translation of academic research into practical applications, empathy in the context of multidisciplinary collaboration, clear communication and expectation management, and a focus on broader societal impacts. Future research focuses on integrating technologies with Society 5.0 objectives, enhancing cooperation, and reducing discrepancies between academic theory and industrial practice.

Keywords: AI Integration, educational innovation, Society 5.0

1 INTRODUCTION
As we move towards smart societies driven by technology and innovation, we face significant knowledge gaps and challenges. This transition aligns with Society 5.0 principles, a concept conceived in Japan where digital and physical realms are integrated to drive economic progress while solving societal issues concomitantly [1]. Simply put, it recognises that we can no longer develop things just because we can (for profit only). Embracing digitalisation in design means incorporating design accountability in addressing societal challenges. Enacting such a framework requires close collaboration between industry and academia, as these entities represent the foundational pillars for fostering innovation and addressing the complex challenges of realising smart societies. Despite the immense potential for mutual benefit, an inadequacy exists in how these two sectors collaborate, often leading to missed opportunities and groundbreaking innovation. Such inadequacy is exacerbated by the emergence of artificial intelligence (AI) technologies and their disruptive impact on new product development.
The gap in novel collaboration approaches reveals a broader issue: the unclear path forward in collaboratively developing and implementing novel technologies to mitigate current and future societal challenges. Society 5.0 promotes the harmonious integration of technological advancements with everyday life, emphasising the role of design and engineering education in preparing a new generation

skilled in AI and capable of contributing to these societal goals. Thus, a novel path in design education and research is needed to facilitate quick, adaptable learning and effectively equip people to tackle world challenges. This collaborative paradigm shift towards innovative, human-centric design is essential for navigating the complexities of smart societies and achieving the aspirations of Society 5.0.

However, the path to realising these goals is fraught with obstacles, particularly in industry-academia collaboration. University bureaucracy often stands in the way of swift project implementation, contrasting sharply with the industry's need for quick adaptation to market demands (and profit, no matter what). This disparity between academia's focus on long-term, theoretical solutions and the industry's emphasis on immediate, practical innovation creates a disconnect between research, practice, and education, hindering effective collaboration and opportunities for teaching informed by applied research. The disconnect is twofold: a collaborative model for developing knowledge and a lack of formal integration between applied research and education. Therefore, integration between industry and academia can lead to better integration of research into teaching, creating a dynamic educational paradigm driven by inquiry and evidence-based practices. This article explores these dynamics, advocating for a more integrated and agile approach to bridge the theoretical and practical gap.

2 THEORETICAL ASSUMPTIONS

Despite efficacy uncertainties, theoretical evidence suggests that agile methodologies can enhance productivity and quality in industry-academia collaborations. [2]. As shown in Figure 1, a 2006-2024 search within Scopus using the term “industry-academia collaboration” suggests an upward trend in line with the findings of [2].

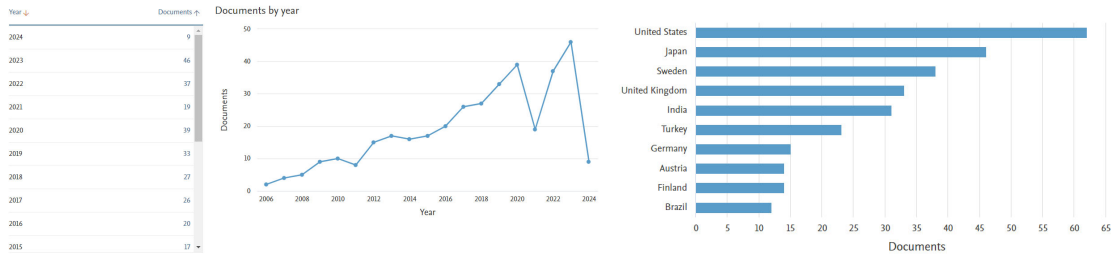

Figure 1. Documents per year and country

It must be acknowledged that much research uses Case-Study Research as a research strategy, indicating that such an approach still needs to be explored. Publication and selection bias exist as most published results are positive, and most identified scholars are from Electronic and Electrical Engineering and Software Development (Figure 2). So, readers must be mindful that lessons cannot be generalised.

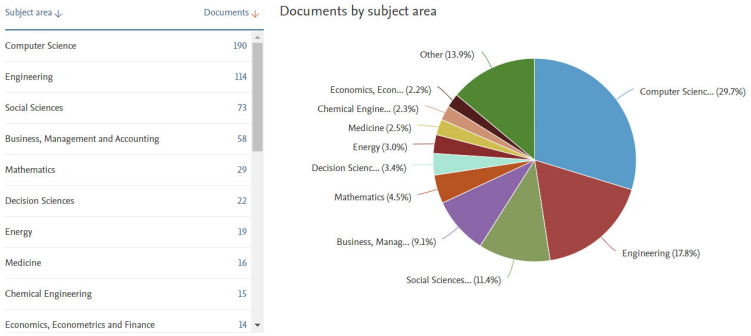

Figure 2. Predominance within Computer Science and Engineering

Nonetheless, evidence indicates an emphasis on the importance of mutual engagement and goal alignment, with agile principles playing a crucial role in success [3], a need for legal frameworks for establishing commitment and conflict resolution approaches [4], enhancement of productivity and satisfaction and reduction of bureaucratic challenges [5]. Employability has a level of dependency on Artificial Intelligence (AI) in some recent research [6][7][8]. If the industry uses Artificial Intelligence (AI), academia must include AI in education and research to meet industry needs. Considering the above, this research supports the notion that using agile action research and AI represents a plausible way to strengthen the collaboration between industry and academia to solve the complexities of smart societies.

3 OUTLINE RESEARCH METHOD

These are the initial results of developing an agile action research framework to streamline industry-academia collaborations for Society 5.0 solutions involving 20 contributors from various countries (Brazil, Chile, Colombia, Netherlands, UK and USA), including students, academics and industrialists. Data was collected through two online workshops to a) understand the contextual implications of collaborating and to leverage participants' perspectives regarding factors that enable the convergence or divergence of collaboration between industry and academia and b) to identify factors that facilitate and hinder interaction between industry and academia. Workshops were recorded, transcribed and subject to inductive qualitative analysis to identify factors contributing to (convergence) or hindering (divergence) collaboration. From the excerpts, a Table of Dispersion of Divergences and Convergences was developed using the Matplotlib library [9] in Python to facilitate comparison and visualisation of the factors. The analysis to understand the connections between characteristic keywords and to identify underlying meanings and implicit messages was based on a keyword network map created using the NetworkX library [10] in Python to facilitate the graphical representation of the interconnections between different themes and concepts discussed by participants. These approaches were known to the research team and considered appropriate for this level of investigation.

4 INDUSTRY AND ACADEMIA DYNAMICS IN SOCIETY 5.0

Data from Workshop 2 revealed patterns in participants' discussions, allowing us to identify successful and unsuccessful interactions. Recurring themes included difficulties converting academic projects into real-world applications, institutional (legal) barriers, and student engagement. Concerning unsuccessful interactions, the challenge of translating academic projects into practical applications was prominent. Participants expressed deep frustration, noting, "*Creating projects with academia is complicated because the translation process is difficult*." others echoed this, e.g. "*very difficult to collaborate with people from academia and then work or study for a long time on it and then come to a corporate scenario*." Regarding institutional barriers as significant impediments, various remarks such as "*The university would not allow us to share that kind of information with all the different departments and faculties" and* "*aborted collaboration*" that "*did not even start because right after the project, the top manager, now vice president of the company, asked me to run a new project*" highlight the bureaucratic hurdles hindering collaboration and emphasise the unpredictability and provisional nature of these partnerships. Positive examples of fruitful industry-academia collaborations were less evident within the data. However, examples included a participant recalling a small-firm-academia collaboration, which "*was a very successful collaboration*," indicating that successful partnerships are possible and potentially rewarding. The emphasis on student professionalisation through practical engagement in real-world projects is "*An example of a collaboration where companies come... and invite the students to participate, bringing problems or projects for the students to work on during the semester."* The role of student-led initiatives in fostering these relationships was highlighted by some "*30 students in our university who were volunteers dedicated their time trying to unite the industry with academia basically*," and "*I participated in a project called junior companies which students entirely make*." These instances suggest that student involvement can help bridge industry-academia collaborations. Figure 3 below shows a simplistic network graph constructed after analysing key terms from Workshop 2.

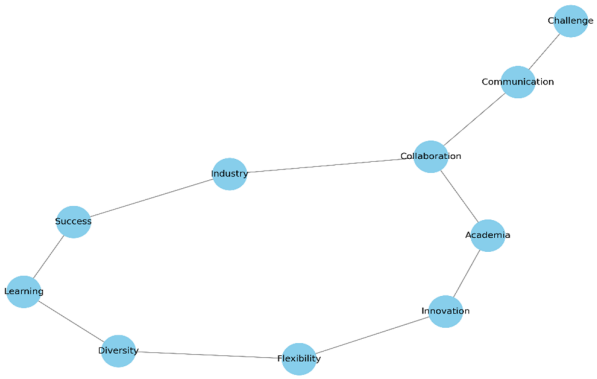

Figure 3. Network map of key themes and concepts

The above map illustrates the interconnectivity of key themes and concepts. The 'Collaboration' node is at the centre to highlight its pivotal role in connecting industry and academia. It directly links to 'Academia' and 'Industry', stressing the collaborative nature of these interactions. The 'Academia' and

'Industry' nodes are connected and linked to 'Innovation' and 'Success'. This sequence suggests that while innovation is a key focus in academia, practical outcomes and market success are primary concerns for industry. The link between 'Innovation' and 'Flexibility' suggests that innovation in academic research often requires flexibility, be it in approach, methodology, or application. Similarly, the connection between 'Challenge' and 'Communication' suggests that effective communication is crucial in overcoming collaboration challenges. Furthermore, the 'Success' and 'Learning' nodes are connected, indicating that successful collaborations often lead to valuable learning opportunities, benefiting both sectors. The linkage between 'Learning' and 'Diversity' implies that learning encompasses understanding and embracing diversity in ideas, approaches, and cultural backgrounds. The connection between 'Flexibility' and 'Diversity' indicates the importance of adaptable approaches in diverse environments, which is crucial for successful collaborations. Additionally, the link between 'Communication' and 'Collaboration' reinforces that communication is foundational to effective collaboration.

The subsequent analysis considered the convergence and divergence within the interactions. The study shows instances with a higher divergence score than their convergence score, indicating scenarios where industry and academia face significant challenges in aligning their objectives and methodologies (Figure 4). The higher divergence score reflects a predominant presence of conflicting interests, differing operational cultures, or distinct end goals that overshadow the combined strengths of the partnership. Such instances often involve scenarios where the theoretical and research-focused approach of academia clashes with the practical, results-oriented focus of industry, leading to challenges in effective collaboration. These scenarios highlight the need for earlier and improved communication, mutual understanding, and establishing common goals. The elevated divergence score is a critical indicator of areas within industry-academia collaborations that require strategic attention and resolution.

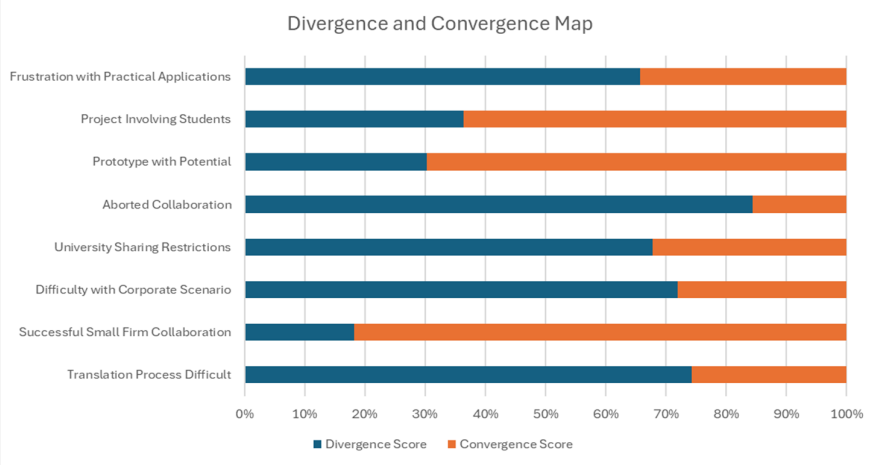

Figure 4. Divergence and Convergence Diagram

The instance "Translation Process Difficult" signifies the challenges in translating academic theories into practical industry applications. This reflects a high divergence score due to the stark contrast in objectives and methodologies between these sectors. "Successful Small Firm Collaboration" demonstrates a lower divergence and a higher convergence, indicating that effective alignment of goals and mutual understanding might be easier between universities and smaller organisations. Instances like "Difficulty with Corporate Scenario" and "University Sharing Restrictions" represent barriers to effective collaboration, with high divergence scores due to differing operational cultures and bureaucratic hurdles. "Difficulty with Corporate Scenario" again indicates situations where the theoretical, research-focused approach of academia may clash with the practical, results-oriented focus of the corporate world. In university innovation ecosystems and industry alike, a range of restrictions are imposed by both partners to safeguard intellectual property and ensure adherence to confidentiality agreements. These include confidentiality policies, which limit the disclosure of sensitive research data to protect intellectual property; publication restrictions, that control the dissemination of research findings, particularly relevant for patents or commercial applications; and regulations on external collaborations, governing the scope of partnerships between industry and academia, encompassing shared resources, funding, and student involvement. While essential for protecting the interests of both sectors, these restrictions can sometimes challenge the fluidity of industry-academia collaborations, highlighting the need for a balanced approach to managing these partnerships for mutual benefit. As participants were from various countries, it became clear that some universities are more profit-generation-led, whereas others are knowledge-generation-led (another disparity in the global scenario).

Conversely, "Prototype with Potential" and "Project Involving Students" are marked by lower divergence and higher convergence, showcasing scenarios where industry-academia collaborations have led to tangible outcomes and valuable learning experiences. "Prototype with Potential" suggests that the collaborative effort resulted in a tangible and promising outcome, in this case, a prototype that embodies innovative ideas from academic research and is viable for practical industry use.
Aborted Collaboration" is another instance illustrating high divergence, where the collaboration did not commence or was terminated prematurely due to misaligned goals or expectations. "Frustration with Practical Application" highlights the often-experienced frustration in academia when industry-focused projects do not yield research results, again indicating a higher divergence.
The diagram provides a nuanced understanding of the varying dynamics in industry-academia collaborations, ranging from highly successful integrations to challenging divergences. It is difficult not to overstate the importance of harmonising the activities and objectives of both sectors to cultivate fruitful research partnerships [2]. Although with some variation, industry is principally concerned with identifying critical business issues and devising solutions, while academia aims to uncover and fill knowledge gaps, contributing to the wider body of scholarly knowledge. In considering the goals of Society 5.0, additional complexity is added to the design of products and services directly or indirectly intended to benefit society.
Figure 5 presents a conceptual framework for addressing societal challenges developed based on precedent existing agile approaches used in research [3, 11] and focused discussions with workshop members. The framework highlights four primary societal problems or opportunities: hunger, poverty, natural disasters, and immigration. These issues catalyse industry and academia to collaborate, fostering an environment where knowledge and resources can be shared to innovate and solve pressing problems. Ultimately, the objective is to contribute positively to Society 5.0, a vision for a human-centric society that balances economic advancement with resolving social issues through integrating cyberspace and physical space. Within the model, AI is restricted to prototyping and data analysis.

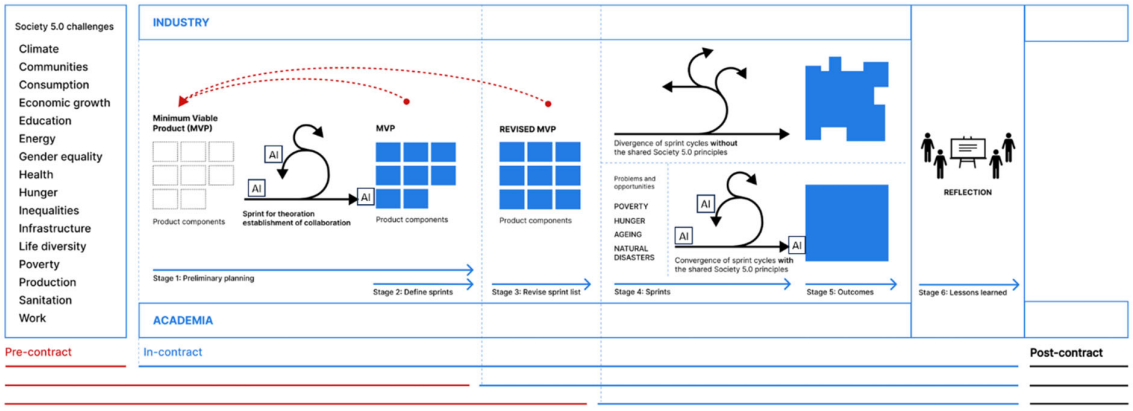

Figure 5. Agile Action Research Model for Society 5.0

The confluence of agile methodologies and AI within educational paradigms marks a significant evolution. This integration is a pedagogical shift and a strategic realignment towards responsive and adaptive forms of education, addressing the complexities of Society 5.0. Agile action research in this context transcends traditional boundaries, enabling a fluid interchange and rapid prototyping of ideas, which is key to keeping pace with rapid technological advancements. Incorporating AI in this framework magnifies its potential, allowing nuanced analysis and understanding of technical and societal variables. AI's role in design education includes its use as a powerful tool for simulating complex systems and societal scenarios, enabling students and researchers to experiment and iterate solutions in a controlled yet grounded environment. This experiential learning, underpinned by AI, cultivates a deeper understanding of the intricate interplay between the researcher's need to generate new expert knowledge, the industry's drive for technological solutions, and societal needs. Moreover, the agile approach within this educational model ensures that learning is not static but dynamically evolves with real-world challenges and technological advancements. The outcome will be a generation of engineers and designers who will be technically proficient and acutely aware of their role in shaping a society that is increasingly digital, interconnected, and reliant on harmonious human-technology interactions. This educational approach is also promising for addressing the complex societal challenges of Society 5.0, many of which may benefit from an agile approach managed within university-industry partnerships.

5 FINAL REMARKS

The new paradigm proposed for Society 5.0 necessitates a transformative approach to academic-industrial collaborations. Industry and academia must align their endeavours, fostering synergies that drive technological innovation and address this era's quintessential societal needs. There are many justifications for such collaborations.

Firstly, Society 5.0 accentuates the role of advanced technology in resolving societal challenges. Academia, with its research prowess, and industry, with its implementation capabilities, are pivotal in translating technological advancements into societal benefits. Secondly, this collaboration ensures that academic research can be translated into real-world applications, thus enhancing its relevance and impact. Thirdly, it provides a framework for academia to contribute actively to economic growth and societal well-being, aligning with the ethos of Society 5.0. Hence, the necessity for academic and industrial interactions becomes a pursuit of technological advancement and a commitment to societal advancement. This alignment with the Society 5.0 agenda ensures that such collaborations are purpose-driven, focusing on creating a sustainable, human-centric future.

It is imperative to address and remove existing bureaucratic and trust-related obstacles within industry and academia to facilitate the development of such impactful projects. This change requires conducting thorough research to understand the current context of interactions and proposing more agile forms of integration. Such an approach becomes increasingly vital considering the rapid advancement of technology and the exacerbation of social problems over time. Bridging the gap between industry and academia in alignment with the agenda of Society 5.0 is not just about fostering technological innovation but creating a sustainable and equitable future. We can ensure these collaborations are productive and responsive to urgent social issues by overcoming bureaucratic and trust barriers.

The convergence and divergence factors identified in this article will form the foundation for the next steps of our research. In this regard, we will aim to identify elements integrated with technologies oriented towards Society 5.0 that enhance the convergences and minimise the divergences by developing rapid prototypes that can be evaluated throughout 2024. This approach seeks to align the theoretical and practical aspects of industry-academia collaborations more closely, fostering a mutually beneficial relationship that is in tune with the evolving dynamics of Society 5.0.

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