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Footsteps Towards a Transdisciplinary Design and Process Science

Dedicated to the Memory of Nobel Laureate Steven Weinberg

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Preamble

We are pleased to present this special issue to celebrate the 25th anniversary of the Society for Design and Process Science. This issue is dedicated to the memory of Nobel Laureate Steven Weinberg. Together with other visionaries, including George Kozmetsky, Herbert A. Simon, Lotfi A. Zadeh, C. V. Ramamoorthy, and Raymond T. Yeh, he offered strong support for the Society's mission and vision.

1. How Human Impacts Science

The vision of the SDPS is to establish a Design and Process Science that provides alternative solutions for the increasingly complex problems that the human civilization currently faces, whereas its mission is to become a catalyst for change that will also enable the discovery of new approaches Towards the realization of this vision and mission, some of the main objectives of the Society are listed below and illustrated in Fig. 1:

- Promote the development of design and process science as applied to all traditional disciplines.
- Encourage and foster research and development to advance the discipline of design and process science.
- Provide leadership and resources to foster cooperation among organizations in establishing meaningful international standards.

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- Encourage an interchange of ideas among engineers, scientists, managers, decision-makers, and organizational leaders.
- Recognize achievements in the field of design and process science.

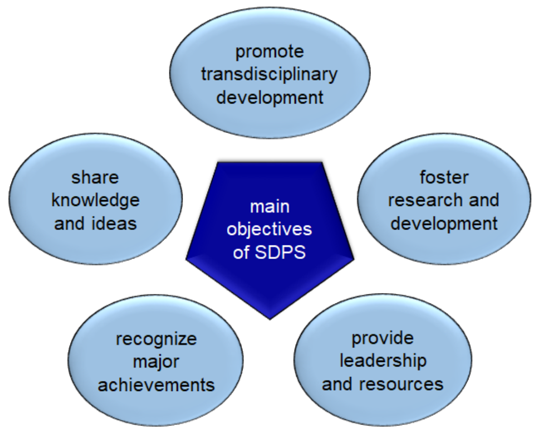

Figure. 1. Main Objectives of SDPS

In supporting the SDPS vision, the present Journal publishes research findings covering transdisciplinary notions of design and process with a focus on issues that deal with (i) the understanding of design and process crossing boundaries of natural, human, and built environments, (ii) principles, methods, and tools, and (iii) applications of design and process science to engineering, healthcare and social problems. The Journal promotes transdisciplinary design and process science research from different disciplines such as mathematics, computer science, economics, engineering, management science, natural sciences, social sciences, and health science. The human environment has become a critical component in the endeavours of both the Society and the Journal and this trend is revealed in our special issue.

This special issue starts with the SDPS 15th conference-opening address delivered by Steven Weinberg in Dallas, Texas, on June 6, 2010. In his address, he discussed his perspective on how a science policy and ideology may significantly impact the progress of science. Though this kind of impact has existed almost since the beginning of civilization, the investigation of human nature and its impact on aspects of the world is deepening and gaining more and more attention. Unfortunately, Weinberg passed away on July 23, 2021, before seeing the materialization of the papers included in this special issue. However, interestingly, Weinberg attended the talk given by another Nobel Laureate, Frank Wilczek, at the University of Alabama on May 11, 2021, in which we cherished his memory and his support of SDPS. Weinberg was instrumental in introducing Wilczek for the SDPS medal in 2017, while Weinberg accepted his in 2010.

The goal of SDPS, following Herbert Simon's lead in integrative research on complex systems and unstructured problems (Simon, 1956), has always been to explore the process and design fundamentals. The rest of this editorial will focus on the footsteps of SDPS over the last 25 years and Society's contributions to the community.

2. Footsteps

2.1. A historical perspective, 1989 - 2000

The second article in this special issue is edited by Stan Gatchel, senior advisor of the SDPS, based on contributions gathered from members and associates. It provides a brief historical perspective of the Society, including its pre-history leading up to its formation in 1995. The key to this formative period was what is termed the "Magic Summer of 1994," where, in the most unlikely of places, a series of events culminated in a meeting with the famous entrepreneur, businessman and technology enthusiast George Kozmetsky. This meeting played a key role in the successful launch of the Society in the fall of 1995. Looking back, the odds of these events happening are nearly zero; however, they are most fortunate they did because the world desperately needs a fundamental integrative science to solve its increasingly complex problems. The Society was formed for this singular purpose: to discover this fundamental science without even knowing if such a science is possible. For over 25 years, our small Society of volunteers has pursued this uncharted path through our member's research labs and universities worldwide. This is the story of what was once called "The Society of the Future." It would appear the future has arrived, and we are now ready for new horizons.

The Society was incorporated in the State of Texas on September 6, 1995, as a non-profit organization. The milestones in the history of the Society are depicted in Fig. 2, including the first SDPS conference that was held in December 1995 in the IC2 facilities in Austin. The transactional Journal of SDPS (The Journal of Integrated Design and Process Science) was launched in 1997. In addition to the key events, many key scholars have been and are working for the Society. The founding board of SDPS was composed of George Kozmetsky (Chairman), C. V. Ramamoorthy, Raymond T. Yeh, Atila Ertas, and Murat M. Tanik. During the first Board meeting, Yeh was elected founding president of SDPS. The current board of the Society for Design and Process Science comprises Raymond Yeh (honorary member), Bernd Krämer, Sang Suh, Ali Dogru, and Murat Tanik. The past and present presidents serving our Society are R. T. Yeh (1995-1998), Stephen A. Szygena (1998-2000), M. M. Tanik (2000-2002), Bernd J. Krämer (2002-2006), Azad Madni (2006-2008), Sumit Ghosh (2008-2010), Ibrihim Esat (2010-2012), Sang Suh (2012-2015), Radmila Juric (2015-2019), and Yong Zeng (2019-2023).

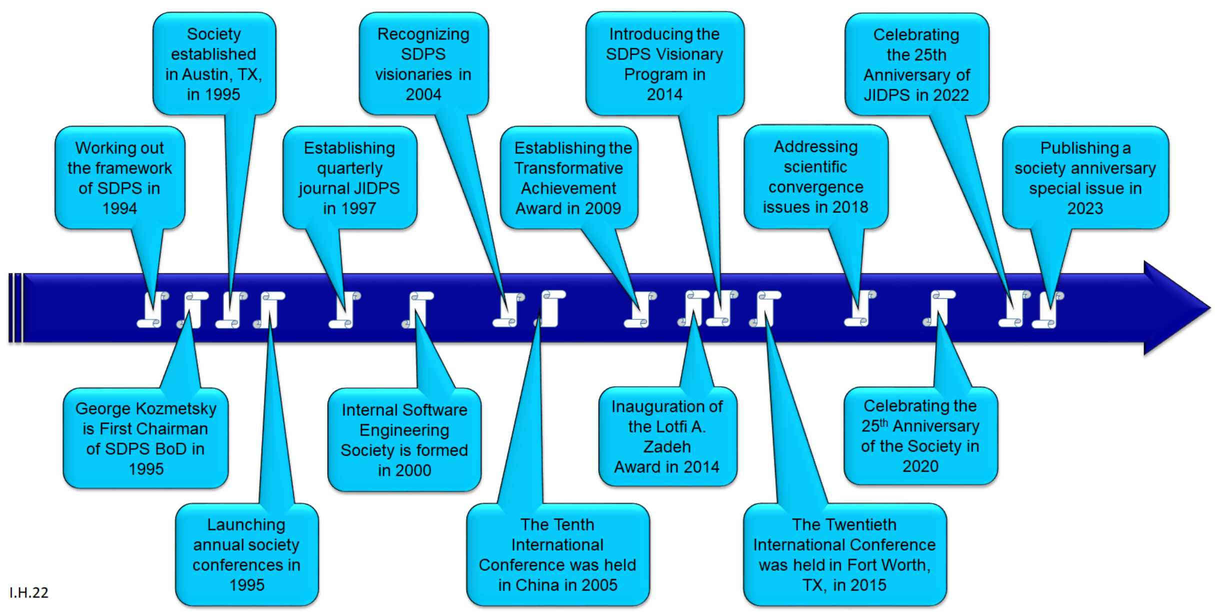

Figure. 2. Milestones in the History of SDPS

2.2. A transformative vision, 2000 - 2022

A transformative vision of SDPS emerged in 2000 during the keynote speech of Herbert A. Simon for the SDPS-2000 conference, when he said

> *"... We are learning that we need a science of complex systems, and we are beginning to construct it ... "*

President of the SDPS at that time, Murat Tanik delivered the following message in his opening address:

"During the last five years, SDPS greatly enjoyed your support and intellectual participation. What makes SDPS successful is the combination of all your individual efforts and participation. That means SDPS is really YOU...nothing more, nothing less. SDPS = YOU. Actually for us, YOU is also an acronym that stands for Young-Organized-Unspoiled. In other words, SDPS is Young and does not carry the burden of old societies. SDPS is Organized worldwide with truly international and dedicated members. SDPS is Unspoiled, meaning pure, refreshing, sparkling, uncontaminated, and whole. We are now ready to expand our organization as we stand poised to make a great impact in the new millennium. Hence, the collective knowledge and intellectual energy each of YOU contributes at every conference is the driving force behind the ascent of SDPS."

The SDPS stayed the course for another two decades and persevered under the next generation's leadership. We recognized, over this time, that we have developed to a stage where we can and must improve collaboration with many disciplines to implement our goals. This 25th-anniversary issue summarizes advances made in the areas of understanding the scientific underpinning of design and process. As a result, we are closer to our goal of defining a general approach to science that can allow us to conduct transformative research and education across disciplines (Fig. 3).

Figure. 3. SDPS at the Leading Edge of the Progression of the Sciences

The evolution and development of the SDPS have been well represented by the papers published in the Society's flagship journal: The Journal of Integrated Design and Process Science (JIDPS). In the third article, Imre Horváth reports on the findings of his unique analysis of the publication history and the publications released over the past 25 years of the JIDPS. It is emphasized that the author intended to let the facts speak for themselves and to provide input for a follow-up road m by the concerned stakeholders. The study deviates from the standard bibliometric and scientometric approaches in that it includes a comprehensive content and trend analysis, not only citation, connectedness, and impact analyses. On the one hand, this investigative paper provides a wealth of statistical facts concerning the domains and activities of publication. On the other hand, it also provides qualitative insights into the scientific contribution of published papers. Though the analysis is retrospective in nature, some remarkable conclusions are derived concerning (i) classification of the published papers, (ii) identification of the main domains of scientific contributions, (iii) casting light on the current state of the Journal, and (iv) projecting the trends to the expectable near-future developments.

The bottom line is that, in addition to explaining JIDPS through the analogy of a camera obscura, the author also managed to find some self-speaking technical facts. They are presented starting with the third section of the paper, which provides a concise overview of (i) the origins and establishment, (ii) the objectives and domains of interest identified by the mission statement, (iii) the publication administration and review websites where JIDPS is registered, and (iv) the major impact scores and factors of the Journal.

The fourth section contrasts the originally planned scientific contribution domains of JIDPS with the current domains of interest. In the bibliometric analysis of the author, a total of 12 general scientific contribution domains have been identified. The total number of papers published from September 1997 until September 2021 is almost 550, but they are not evenly distributed over the named domains. The largest numbers are associated with (i) methodologies, (ii) technologies, and (iii) design/planning activities. The fifth section further elaborates on the domains of scientific contributions and presents a second-level taxonomical decomposition into themes. It is important to mention that the author could not classify all published topics appearing in the Journal into the eleven fundamental domains and themes. The leftover has been included in a category called supplementary.

The presented domain analysis/classification has revealed the thematic complexity of the Journal as it was developing over the last quarter of a century. Horváth identified five epochs in the almost 25 years of existence of the Journal, each of which includes four to six years. He aptly named these epochs as (i) inauguration, (ii) stabilization, (iii) destabilization, (iv) convalescing, and (v) unfolding. The historical view presented in the sixth section explains the addressed scientific topics and the essence of these epochs, which have significance and implications beyond their specific time boundaries. Besides identifying the key players and exposing their contributions, the seventh section also casts light on the target application domains (TADs) of the published papers. In total, 33 TADs have been identified by the author, among which (i) software engineering (ii) design science and knowledge, (iii) healthcare technology and systems, (iv) information engineering, and (v) educational science and systems have been fed by the largest number of papers. Without any implicative or propositional conclusion, the last section of the paper presents the key findings concerning the mission, uniqueness, prospects, ranking, scope, visibility, liveliness, impacts, domains, themes, historical developments, and disciplinary targets of the Journal. These findings will be illuminated further by both the society managers and the journal managers. Most probably, not as a camera obscura does it.

3. Contributions

3.1. What is the role of an observer in a scientific theory?

Tanik has been working on the underlying concept that became Communication Dynamics Theory for over 20 years (Oyzadin, 2001). Initially focused on a wave-centred concept of matter seen from an outside perspective, in the past decade, Tanik and a colleague (Frank Skidmore) increasingly focused on understanding the relationship between communication and the observer, bringing the role of observers into sharp focus as a critical feature of reality. The resulting work identifies subatomic particles, the smallest elements of our physical reality, as the most basic observers. Larger structures generated from these smaller observers become increasingly complex networks of communicating observers. The two papers first introduce the Communication Dynamics Theory and, secondly, the place of those observers in this theory. In the first paper, Pan *et. al.* focus on expanding Communication Dynamics Theory to model atomic diameters for the full periodic table. In the second paper, Skidmore shows that placing observers in Communication Dynamics Theory provides possible explanations for space, time, and fundamental forces of nature, as well as certain currently unexplained constants of our physical reality.

Einstein's general theory of relativity is based fundamentally on the relationship between the universe and large-scale observers (Einstein, 1905a, 1905b, 1915). Tanik and Skidmore hypothesized that the same features apply to subatomic particles. In an unbroken chain, the relationship between an electron and a proton parallels the relationships between a human observer and planet, planet and star, and star and galaxy. The nature and principle importance of observation does not change. Rather, observation is modified, at Planck scale, by the existence of minimum observable distances and quantized energy.

Stone (2015) comprehensively documents Einstein's struggles with quantum theory from the perspective of Einstein himself. Towards the end of his book, Stone describes Einstein's approach to the notion of the quantum, stating:

> *"Why did Einstein, who clearly understood the structure of new theory and the necessity of introducing radical concepts to explain the atom, refuse to accept the theory and hold out for a very different resolution of the quantum dilemma? His inability to axiomatically derive of mass directly from theory was bothering him. He called this a weakness – mass is brought into the theory as an 'extra logical argument'".*

Einstein recognized the limitations of his theory, but also the limitations of quantum theory. Neither theory could explain mass – nor as time passed a host of other observed constants of nature. Stone ended his book with "Einstein…would spend the rest of his life in search of the final movement that would bring his atomic symphony to a harmonious resolution." (Stone, 2015).

Tanik and colleagues believe that they can now introduce the beginnings of the next chapter of the story of quantum theory, bringing "Einstein's atomic symphony to a harmonious resolution". Their proposed theory explores solving Einstein's dilemma through discrete communication theory. The approach builds on fundamental ideas of Feynman's quantum electrodynamics without using Lagrangian. Decades of exploration brought together unlikely players in Computer Engineering, Neurology, and Computational Chemistry for the necessity of introducing radical concepts to explain the atom. In their first paper, Tanik, Pan and colleagues create a dynamic mathematical formulation that predicts the structure and properties of the periodic table of elements under the rubric of a single defining equation applied using principles of communication theory. In their second paper, Tanik and Skidmore add a further radical idea – the notion that small-scale observers (subatomic particles), communicating according to defined rules, define the fundamental structure of our reality. Using himself as a reference, Einstein constructed a formulation of relativity using a ruler and a clock. Tanik and Skidmore propose that every discrete Planck-scale object in our universe can similarly be considered an independent observer, communicating relativistically with surrounding observers. Our brain, collecting communicated information from these small-scale observations, fractures the energy of Spacetime in a discrete interpretation that we can capture and mathematically model. They endeavour to put together these additional radical ideas to devise a solution to Einstein's dilemma and a rubric to pursue new scientific hypotheses and design new technological processes.

3.2. How does a designer enable the transformation from discovery to innovation?

Design and research have natural and functional relationships. Both explore and utilize knowledge for different purposes, namely for artifact construction and theory generation. This relationship on the level of processes was discussed in the literature (Floridi, 2019; Dixon and French, 2020) and can be shown in Fig 4. Based on the formulation of the logic of design into recursion (Zeng and Cheng, 1991), Zeng has further developed a framework of design science (Nguyen and Zeng, 2014; Zeng, 2004; Zeng and Gu, 1999, 2001; Zeng and Yao, 2009) and an Environment-Based Design (EBD) methodology (Zeng, 2015; 2004; 2020), where everything including process was treated as an object. As product users and designers, human beings are considered central objects in the design theory and methodology they have been developing.

Yang *et al.* (2021) integrated the work by Zeng and his collaborators into a behaviour change framework named TASKS, which leads to the sixth paper in this special issue: "Implementation barriers: A TASKS framework". The TASKS framework provides a foundation for behaviour design that aims to overcome implementation barriers. First, to accomplish a task, we need to ask questions which define the workload in implementing the task. Second, human capabilities, which are defined by affect, skills, and knowledge, are critical to implementing a task. Third, a consequence of perceiving or implementing a task is stress which determines how much effort one may devote. The best effort will happen when the mental stress is at its optimal level. Greater mental stress means a greater barrier to implementing a task. Four kinds of barriers are identified in this article: resource barriers, knowledge barriers, logic barriers, and affect barriers. The work proposes that barriers to implementing a task can be identified by analyzing the situations that appear in implementing the task. For each situation, the workload can be extracted first, followed by identifying the idea affect, logical skills and the knowledge needed to accomplish that task. This framework can be applied to various kinds of tasks in various kinds of fields.

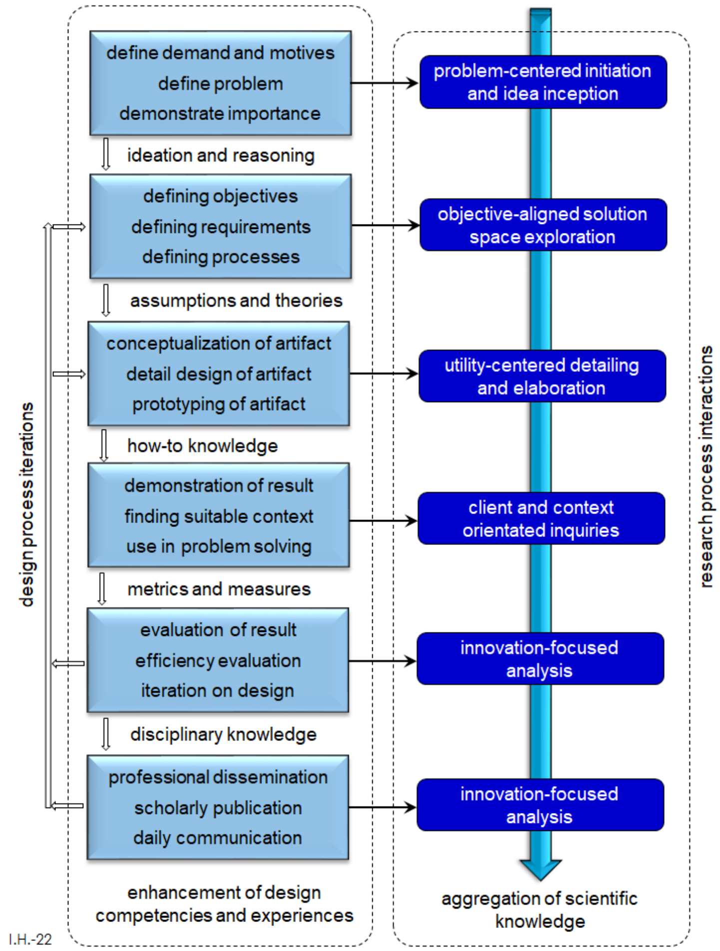

Figure. 4. Relationship between Design and Research on the Level of Goals and Processes

3.3. How to tackle transdisciplinary design problems?

The last paper in this special issue, authored by Thomas Wan, is titled "An Integrated Social and Behavioral System Approach to Evaluation of Healthcare Information Technology for Polychronic Conditions." Healthcare delivery systems are evolving with the advances in health information technology (HIT) development and its applications to coordinated or guided care for polychronic conditions. The design features of artificial intelligence (A.I.) in healthcare reflect the public interest in optimizing care coordination and communication between providers and patients. This article offers a practical evaluation and assessment of relevant theoretical frameworks and appropriate methodologies to formalize a multi-criteria optimization of a logic model applicable to achieving the system's efficiency and effectiveness. In specifying theoretical constructs and evaluation methods for HIT evaluation, a three-fold purpose is to

- show the relevance of personal and behavioural determinants of HIT use,
- articulate the need for developing a transdisciplinary framework consisting of both contextual and personal predictors, and
- formulate appropriate multilevel modelling and causal analysis of the determinants of HIT use and its impacts on chronic care.

This transdisciplinary perspective has been articulated by interdisciplinary scholars (Nielsen et al., 2016; Rav-marathe *et. al.*, 2016; Wan et al., 2017). The utility of applying transdisciplinary perspectives in A.I. research for primary care can be further demonstrated through innovative designs and applications of automation and artificial intelligence (Wan, 2018a). It is very interesting that in the post-COVID-19 era healthcare systems need to be transformed and redesigned from a curative to preventive-oriented population health management by integrating contextual/ecological, personal, organizational, and technological factors into the healthcare delivery systems (Nash and Wohlforth, 2022; Wan, 2018b).

3.4. How did SDPS collectively act in tackling the transdisciplinary challenges?

Through its flagship journal JIDPS, SDPS has been pioneering and making significant efforts to explore the essence and trends of transdisciplinary design and process science concerning knowledge discovery and application methodologies. The Journal's role in supporting the SDPS mission has focused on nurturing and publishing transdisciplinary solutions to emerging issues. This section lists a few major initiatives that have been run in the Journal.

JIDPS has covered the design, knowledge, and education domains as transdisciplinary research areas. Kyoung-Yun Kim from Wayne State University, Gül Kremer from Iowa State University (currently at the University of Dayton), and Linda Schmidt from the University of Maryland organized a special issue on Design Education and Engineering Design (JIDPS, V21N2). V22N4 addressed the roles of causality in understanding the behaviour of system stakeholders. V24N1 covered issues related to knowledge production, sharing, and design in an age of fundamental transformations. Engineering design research focus has emphasized the rich set of natural support of a cognitive and behavioural investigation of designing, learning, and teaming. The related journal special issue highlighted that the act of designing and design education involves ill-structured problems and it makes the process complex. It is of particular interest to the Society how scholars of engineering design and science of problem-solving domains can broaden our understanding of design education, how design education can be designed with design and process science principles, and the knowledge can be constructed and shared to advance design education.

The emerging Digital Engineering represents the engineering paradigm shifts in the digital engineering transformation towards Industry 4.0 (Huang et al., 2020; Zimmerman, 2017). This transformation will profoundly impact how we design engineering systems in the digital, connected, and smart environment. We have actively engaged the development in this critical direction and organized multiple events and special issues. More recently, Jingwei Huang (Old Dominion University), Peter Beling (University of Virginia), Laura Freeman (Virginia Tech.) and Yong Zeng (Concordia University) organized a JIDPS special issue, "Trustworthy A.I. for Digital Engineering Transformation" (V25N1) (Huang, Beling, Freeman, & Zeng, 2021), which is a continuing effort in a series of campaigns, "Leveraging Big Data and Machine Learning for Digital Transformation" (JIDPS, V23N3) (Huang, 2019), "Systems Design in The Emerging Digital Age" (JIDPS, V22N2) (Zhao & Huang, 2018), and "Building Intelligence in Digital Transformation" (JIDPS, V21N4) (Huang, 2017). In SDPS 2020, Jingwei Huang and Patrick HangHui Then organized a workshop on "Digital Transformation and Digital Society" (https://sdpsnet.org/sdps-2020/ws2.html). In the workshop, participants presented their research and discussed their vision for digital transformation. The speakers and panellists include Valliappan Raman and Patrick HangHui Then from Swinburne University of Technology, Reuben Wee – an industrial expert in digital technologies from Malaysia, Laura Freeman from Virginia Tech, Stephen Adams from the University of Virginia, Bob Cameron from Johns Hopkins University, Adrian Gheorghe and Jingwei Huang from Old Dominion University.

The topic of cyber-physical systems, which plays an important role in the implementation of the concept of Industry 4.0 and utilization of the methods and tools of artificial intelligence research and development, appeared both in the last scientific workshop of the Society and in several special issues of the Journal. The first special issue on cyber-physical system technologies and implementation was edited by Sofiane Achiche and Tetsuo Tomiyama, under the title 'Design of Multidisciplinary Cyber Physical Systems' (Achice & Tomiyama, 2016). The next influential special issue on the 'Past, Present and Future of Behaviourally Adaptive Engineered Systems' was compiled by Imre Horváth, José Pablo Suárez Rivero, and Pedro Manuel Hernández Castellano (Horváth et al., 2019). The content of the papers informs the readers on many important new and emerging topics ranging from the ontological fundamentals, through system development methodologies, to new implementations and applications. Another recent special issue addressed the novel, inventive approaches to competitive engineering. This special issue provides deep insights into the phenomenon and types of invention and innovation opportunities and challenges in the context of smart systems and environments (Horváth, 2020). Considering the facts that the amount of synthetic knowledge self-acquired and self-synthesized by intellectualized cyber-physical systems is growing, as well as the repertoire of self-generated (problem-solving) reasoning mechanisms, Horváth (2020) proposed a new disciplinary study with multiple interest domain in a paper titled 'On Reasonable Inquiry and Analysis Domains of Sympérasmology.' Another recently published paper, co-authored by Danny Weyns, Thomas Bäck, Renè Vidal, Xin Yao,| and Ahmed Nabil Belbachir, projects ahead the vision of self-evolving computing systems, which may be driven by an evolutionary engine that runs online experiments to determine how the system needs to evolve to deal with the changes, thereby evolving its architecture (Weyns, 2022). During this process, the engine can integrate new computing elements that are provided by computing warehouses. Several of these and other important road-paving topics are often discussed and revisited at the Society's board meetings, the Journal's editorial board meetings, and technical meetings.

In the perspective of an iterative design process where a design already exists or in the case of new product development, knowledge and discovery can be generated from different routes separated from each other's or combined (i) by the usage of design innovations from users, (ii) from technology developments via research or R&D, and (iii) from the emergence of new requirements or new complex behaviours from 1 and 2. Following a formalized or intuitive design process, design innovation is a way to fulfill a need, implying that customers could accept the solution to the need. In short, a design to be considered an innovation integrates specific properties. The design should be desirable for users, feasible for the company to cover a need, and economically and environmentally viable. Along this line, Eric Coatanea has concentrated on two aspects of the design innovation process: first, to unveil hidden problems that can generate new needs (Moktharian et al., 2017), and second, to evaluate early innovative solutions before committing too many resources for the companies (Coatanéa et al., 2020). Computer-aided tools have been under development specific to the early phases of the design process to address those two key questions (Coatanéa et al., 2022).

4. Reflections and Perspectives

The more than 25 years of existence and operation of the Society of Design and Process Science prove that its establishment was an excellent idea, and a very influential society was formed based on many new principles. The motto of SDPS is pursuing ***Transformative research and education through transdisciplinary means.*** It is reflected in the completed work and the archived results and well represented in this anniversary issue. We are sure that Weinberg would feel well about it. The presidency, fellows, and members of the Society truly believe that incredible engineering and science can be built based on the strong philosophical and theoretical fundamentals and further development of these foundations. As overall reflections, the following statements can be formulated:

- The very progressive vision, working principles, and strategic plans of SDPS have attracted the attention of numerous outstanding scientists, scholars, and professionals over the years, who have proudly become members of the Society and shared their knowledge with other members and with the wider public. Respect towards each other, constructive critique, and social gathering were always the guiding principles of community building. The intellectual resources of the Society are high and growing.
- The Society found fruitful ways to cultivate supporting philosophies, theoretical frameworks, methodological approaches, and practical means to generate and disseminate knowledge in a rather wide spectrum of academic interest. Consequently, SDPS successfully realized the goals set to promote disciplinary development, foster scientific research and industrial development, provide leadership and resources, recognize major achievements, and share knowledge and ideas. The cross-disciplinary and above-the-field thinking has led to concepts such as scientific transdisciplinary, fostering disciplinary convergence, integrative research in complex systems, and addressing complex societal problems.

- Design and processes have been put into the scientific focus of the Society, and many remarkable and influential insights and results have been achieved. Both design and processes are and will remain basic concerns for humanities. Optimizing design and processes on grand scales and achieving the best possible manifestations in practice, on the one hand, is a huge challenge; on the other hand, it is a valuable contribution to solving industrial and societal problems. Many grand challenges are posed by growing complexities, heterogeneities, dynamics, globalization, informatization, and intellectualization, which also concern education and well-being. Industrial and societal matters are triggered by sustainability, security, food provisioning, resource management, polarization, urbanization, and many other issues. The knowledge has been offered by the Society is an important resource for addressing these challenges and concerns.
- The Society's efforts to aggregate, synthesize, distribute, and operationalize knowledge are strong, widely based, and successful. The yearly conferences and workshops have involved a very large number of contributions from both members and non-members. The pioneering and significant efforts of SDPS to get world-leading experts involved allowed us to explore the essence and trends of transdisciplinary concerning both knowledge discovery and application methodologies. The Journal of Integrated Process and Design Science, established 25 years ago, has shown particular interest in how scholars of engineering design, process management, digital transformation, intellectualization of systems, artificial/computational intelligence, systems science, and computational problem-solving can work together and broaden our understanding of technologies, education, organization, production, servicing, and experiences.
- The Society is ready for the next 25 years. It will flexibly adapt to the digital world's features and the accelerated age. It will monitor the changes and will propose and introduce changes. It will promote convergence but will also open to divergence. It will rely on its existing outstanding human resources but will also open the doors for young talents and anybody interested in collaboration and contribution to the realization of the jointly set objectives.

Many philosophers and theorists of science argued that the genesis, evolution, and maturing of scientific disciplines generally go through many stages, during which they are created by scientists of different kinds and also empower those scientists in their different kinds. It is a strong intention of the Society to actively contribute to the scientific progression of a converging design and process science. To be responsive to the overall dynamic changes and successfully cope with all emerging challenges, the Society must further develop. Entering the Society's next stage of development, we envision that SDPS will evolve from the following perspectives (Figure 5):

- ***Investigating the scientific fundamentals of design and process***. The governing principles behind the design and process are invariant, independent of how social and technical environments will change. Design and process science aims to investigate the interactions among humans, nature and artifacts. As observers, designers, creators, and consumers, how humans are integrated into the design and process science will remain an essential part of this journey. The natural sciences study relations in nature and the physical and physiological elements of humans; the social sciences are concerned with human relations and human psychological and spiritual elements; engineering aims to change the environment by using knowledge from natural and social sciences. Design and process science depend fundamentally on human capability in perception, understanding, and designing.
- ***Devising enablers for transdisciplinary design and process research***. The transdisciplinary design and process science will naturally resort to existing research instruments, including the axiomatic approach, quantitative method, qualitative method, computing methods, and neurocognitive experimental methods. How these methods can be effectively integrated to study design and process fundamentals will be a major interest to cultivate the further growth of design and process science.
- ***Exploring and scrutinizing technological paradigms***. While design and process fundamentals remain invariant, the technical and social environments are dynamic entities in the spacetime continuum. We

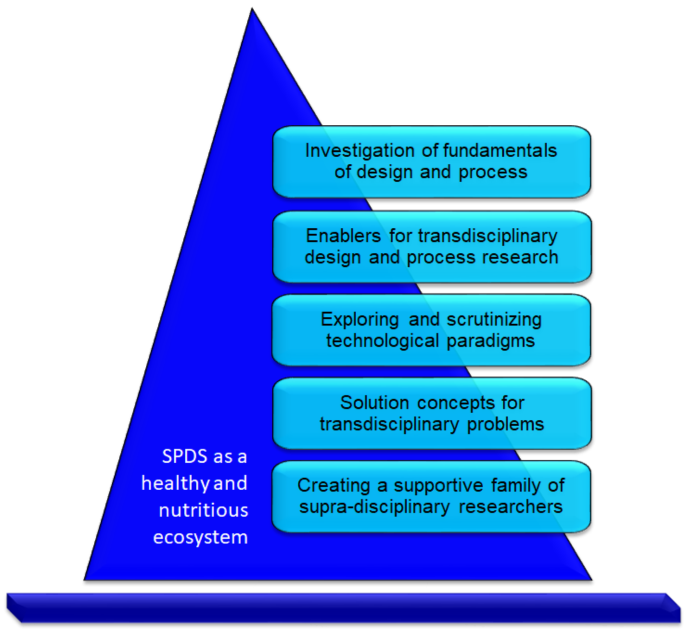

Figure. 5. Perspectives of Progression of the SDPS

will take full advantage of the developments in artificial intelligence, cyber-physical systems, digital systems engineering, human-AI teams, and quantum computing in developing integrated design and process science.

- ***Producing innovative solutions for transdisciplinary problems of societies and industries***. Along with the rapid development of communication, transportation, and computing technologies, civilization is facing challenges exponentially complicated by increasing human interactions and activities. We will promote efforts and solutions in tackling urging and emerging issues in health, education, sustainability, poverty, and development. Precision and personalized solutions will be of great interest in each of these fields, while universal approaches will stay a continuous aim.
- ***Creating a supportive family of supra-disciplinary researchers***. Any effort is meaningless unless it serves human well-being and benefits. Any great mission is impossible unless it can attract many passionate seekers and followers. SDPS was designed to be a family to foster the researchers conducting transdisciplinary research in the no-man land. We will collaborate with interdisciplinary education programs and cooperates. We will continue to make the Society a highly functional and efficient family of scholarly people by providing the fertile soil and necessary nutrition for the seeds of great thought.

The next 25 years of SDPS will establish a healthy and nutritious ecosystem to cultivate the further development of the design and process science, foster the sustainable growth of its community, and maintain a good balance between the continuity of its value and the evolution of its practices adaptive to the changing environment. Part of the SDPS vision will be further elaborated and unfolded in a forthcoming special issue, which celebrates the 25th anniversary of the Journal of Integrated Design and Process Science.

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