Design Innovation for Higher Productivity

Dr. Kevin Chun-Ju Tseng

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Asian Productivity Organization

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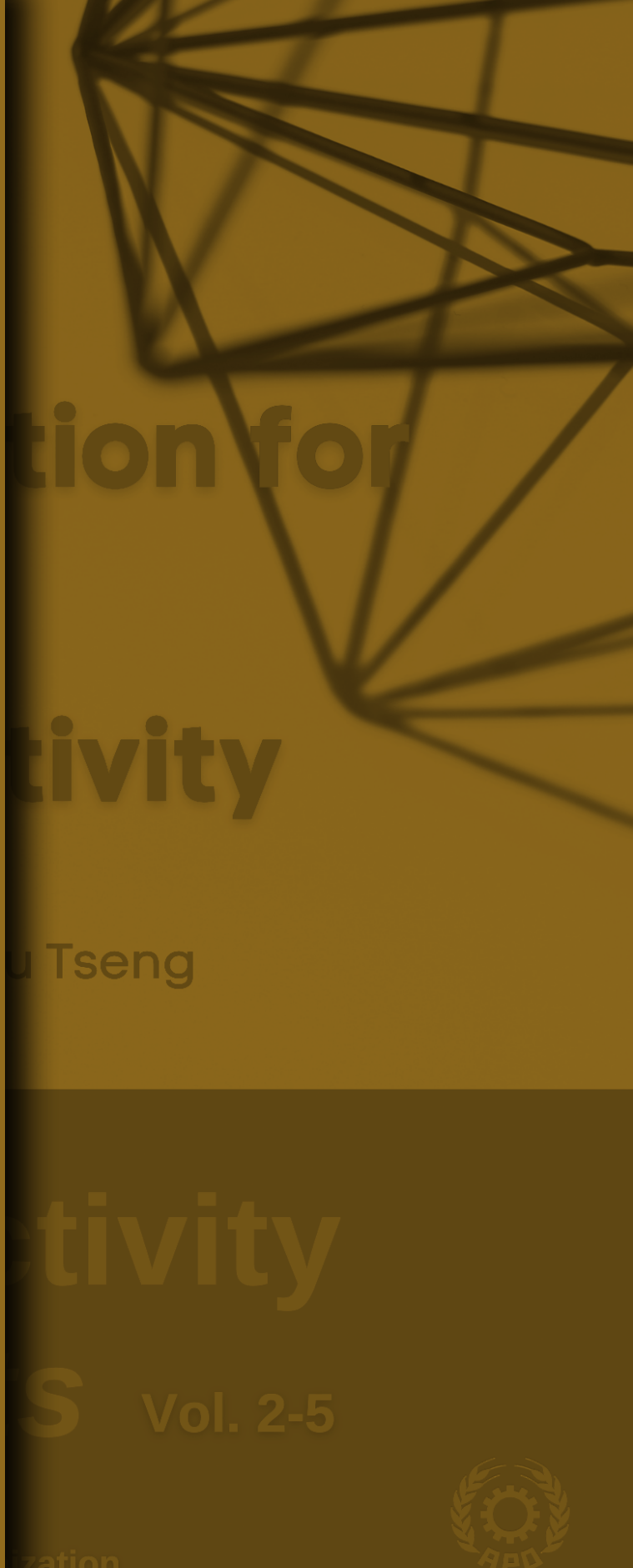

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PREFACE

The P-Insights, short for "Productivity Insights," is an extension of the Productivity Talk (P-Talk) series, which is a flagship program under the APO Secretariat's digital information initiative. Born out of both necessity and creativity under the prolonged COVID-19 pandemic, the interactive, livestreamed P-Talks bring practitioners, experts, policymakers, and ordinary citizens from all walks of life with a passion for productivity to share their experience, views, and practical tips on productivity improvement.

With speakers from every corner of the world, the P-Talks effectively convey productivity information to APO member countries and beyond. However, it was recognized that many of the P-Talk speakers had much more to offer beyond the 60-minute presentations and Q&A sessions that are the hallmarks of the series. To take full advantage of their broad knowledge and expertise, some were invited to elaborate on their P-Talks, resulting in this publication. It is hoped that the P-Insights will give readers a deeper understanding of the practices and applications of productivity as they are evolving during the pandemic and being adapted to meet different needs in the anticipated new normal.

INTRODUCTION

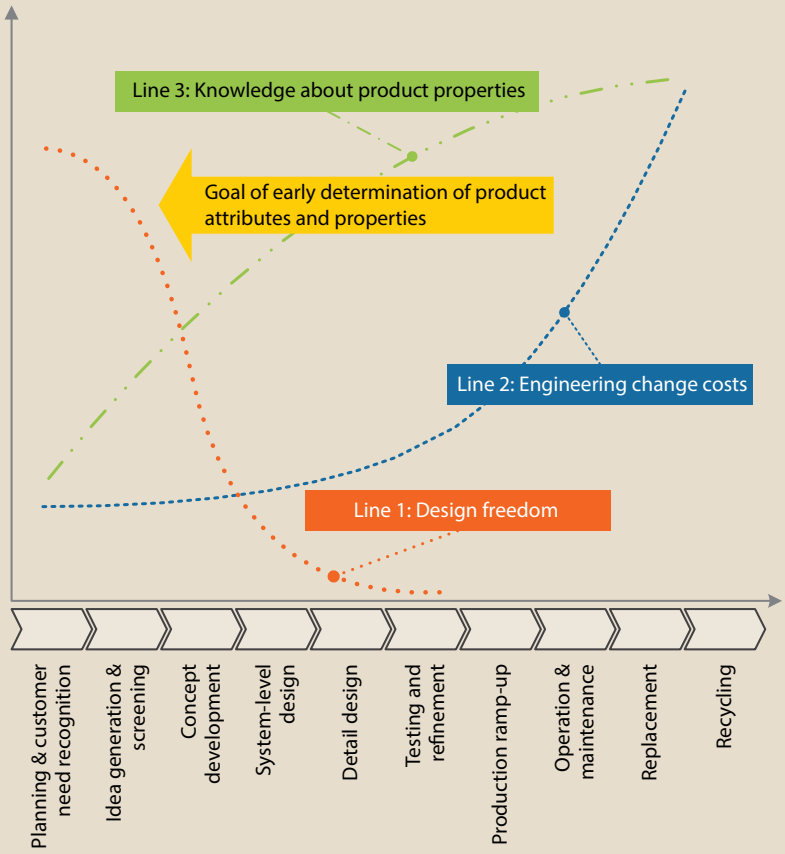
Design innovation is closely related to new product development (NPD). Developing a new product to arrive in time in the marketplace begins with idea generation through exploration. The subsequent steps involve project planning and management, concept development, embodiment design, detailed design, testing and refinement, and production, helping to take the idea to the marketplace. The initial definition of a product is a critical starting point in NPD.

Ulrich and Eppinger [1] pointed out the effect of five characteristics of successful product development, including product quality and cost, development time, cost, and capability. NPD is a complex, knowledge-intensive activity requiring efforts from nearly all organizational functions and even support from other organizations. Three core areas are generally central to an NPD project: marketing; design; and manufacturing. In most cases, NPD requires more specialists to contribute to the product design and development processes. In product development practice, more cross-functional collaboration and activities associated with various marketing, design, and manufacturing perspectives are now being considered during product development phases. Moreover, Figure 1 shows that it is essential to note that early knowledge to determine suitable product properties is preferable because engineering change costs rise progressively during product development [2]. Thus, generating good-quality innovative ideas and launching reasonable levels of interdisciplinary collaboration between marketing, design, and manufacturing activities are necessary, which require a well-integrated system and methodologies that can support product development from various perspectives [3–5].

Design innovation is fundamentally about inclusion. It enables organizations to develop innovatively designed products underpinned by an understanding of marketing, design engineering, manufacturing, and business strategy. Design innovation can be considered a creative process. It is intended to enable an organization to increase innovativeness by thinking of holistic design

FIGURE 1

EARLY DETERMINATION OF PRODUCT PROPERTIES.



Source: Reproduced with permission from Lindemann et al. [2].

throughout various stages, including design engineering, design strategy, and internal micro-level hybrid (design or system) thinking.

Nowadays, the value of design innovation has encouraged top-level managers to pay more attention to it. There is a growing recognition of design's contribution to the organizational innovation areas considered an essential element for a successful enterprise. Design innovation management often influences business operations and can have profound impacts on business success. Notably, it now makes vital contributions to developing organizations'

strategies to increase their competitiveness and design strategic roadmaps to solve complex nonlinear problems.

This article focuses on understanding how to use design innovation as a strategy for higher productivity. The remaining parts of this article are organized as follows. Section 2 presents a brief overview of recent contributions to the literature on design innovation for higher productivity. Section 3 discusses the design innovation approach in this article, which includes the meaning of two-fold innovation. This section also introduces the innovative product design and development (IPDD) approach. Section 4 is split into two parts. First, the topic of IPDD is reviewed. Second, another issue of technological innovation for higher productivity is discussed. Finally, section 5 gives conclusions.

LITERATURE REVIEW

The NPD Process

Research shows that a design defect that remains undiscovered until the product is in production or used by customers can lead an organization to irreversible disaster. Figure 1 shows a detailed analysis of the importance of the early determination of product properties during the product development process. To increase the NPD success rate, many R&D aspects, from existing tools and procedures to R&D professionals' capabilities, have to be considered in the early conceptual design stage.

NPD critically influences the success or failure of an industrial organization. Researchers from design, engineering, management, and other disciplines are keen to study NPD processes to identify the optimal ones. Most conclude that to be successful at NPD, an organization must simultaneously meet customer needs and take a shorter time to market.

Successful organizations have uniquely superior products that have been built by listening to the "voice" of customers. They clearly define their strategic intent and understand their holistic NPD capabilities to find optimum ideas to meet organizational goals with current resources and competencies. In addition, a spiral or parallel development process is used to reduce cycle time and better fulfill customer and supplier requirements in the early NPD stage.

What Is Design Innovation?

The UK Department of Trade and Industry describes one of the more straightforward principles of innovation as "the successful exploitation of new ideas." The OECD also emphasizes this, describing design innovation types as product, process, marketing, and organization. Through either radical or incremental changes, good design innovation is often considered a product or

service success. In addition, design innovation now also considers new organizational structures and business models. However, how to succeed in incorporating design innovation as a strategy into organizational culture and its effect on employees' DNA to increase their productivity is an increasingly important agenda item that APO member countries now need to consider.

There are three main ways to design innovation: as a symbolic representation to visualize ideas; based on descriptions of innovative products and services to be delivered; and as sustainable efforts to support an organization's holistic innovation management. Design innovation can be viewed as a bridge among marketing information, R&D knowledge, and new technology to develop an enjoyable, usable end-product, emphasizing links between creativity and innovation. Taking design innovation to the organizational level can influence changes in the vision and strategy of the organization itself. It is also seen as an essential part of organizational success.

Where Ideas Come from

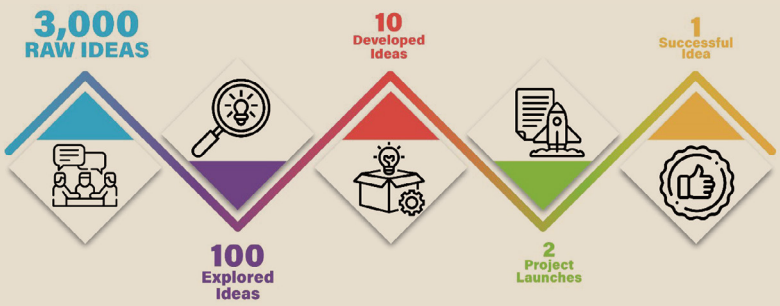
Ideas often originate from various channels, such as dialogues in which an individual hears about a challenge and recognizes a new solution for dealing with it. It is therefore crucial to create free space to discuss challenges without fear and stimulate new solutions openly. The purpose of an innovative idea is to ensure that there is evidence so that when we ask engineers to build a production-quality prototype, it will not be a wasted effort. Therefore, we need to collect as many raw ideas as possible in an idea bank. A raw idea can be as specific as customers telling R&D professionals that they need a new feature, or as vague as the CEO saying, "Let's add some machine learning to our product," or anything in between.

Figure 2 shows that it takes about 3,000 raw ideas to develop 100 explored ideas in the ideation stage. Moving from 3,000 to 100 explored ideas is essentially a self-screening process. Some techniques reduce screening time and increase accuracy, such as a few simple experiments, filing a patent disclosure, or discussing ideas with management in the concept development stage [6].

Since R&D professionals collect as many ideas as they can find, they will end up with dozens or hundreds of raw ideas in their idea bank. The R&D team will not have enough time to research everything but must decide which ideas

FIGURE 2

3,000 RAW IDEAS EQUALS 1 COMMERCIAL SUCCESS!



Source: Reproduced with permission from Stevens and Burley [6].

deserve more research and which ones do not. Organizational goals are the first filter. If an idea cannot positively impact the metrics that the organization's R&D team is currently focusing on, the original idea will be discarded. In addition, prototypes are essential for idea validation. They simulate the user experience to answer specific questions so that the R&D team can iterate and improve the experience.

Summary

NPD is recognized as the most critical factor for an organization to succeed. Design innovation as a strategy driving the NPD process and organizational culture with vivid creativity and innovation systematically exploits ideas that simultaneously use and create knowledge. The three critical elements identified are design engineering, design strategy, and internal micro-level hybrid (design or system) thinking that will translate innovative ideas into successful ones. Therefore, design innovation methods are needed to understand how to improve organizational innovation capacity for higher productivity.

DESIGN INNOVATION APPROACH

There are two types of innovation: technology-push innovation; and market-pull innovation. Technology-push innovation is when R&D professionals design a new product based on whether the technology is available. One example is touch-screen technology first developed by the Royal Radar Establishment. In the 1980s, Hewlett Packard introduced a touch-screen computer. The Apple PDA and the Palm Pilot were developed later as the technology became able to recognize handwriting. Most mobile phones, laptops, and computers now use this advanced technology. Market-pull innovation is when R&D professionals design a new product after investigating whether the market requires it and whether it can meet felt needs. One example is cameras, for which customer needs evolved over the years. Market research showed that people needed to take and store many photos and wanted small-sized cameras. Due to those customer needs, camera design focused on developing lightweight, more compact cameras, along with higher-resolution, advanced editing software. Camera design has become smaller for integration into mobile phones. Users now want to be able to take photos of themselves, leading to the development of even smaller cameras placed on the front of phones.

Whether it is technology-push or market-pull innovation, R&D professionals often work with teams to pursue an outstanding vision that could impact their customers and business. This type of vision is vital for motivating R&D teams and pointing them in the right direction. However, a good vision needs to be iteratively tested for desirability, feasibility, and viability. Tests of all three characteristics need to be conducted during vision generation to adjust and keep the R&D professionals on the right course. I am therefore trying to propose a “design thinking, systems design” of the IPDD framework for this innovation process [7]. Design thinking is a human-centered process for creative problem-solving. It encourages R&D professionals to focus on their

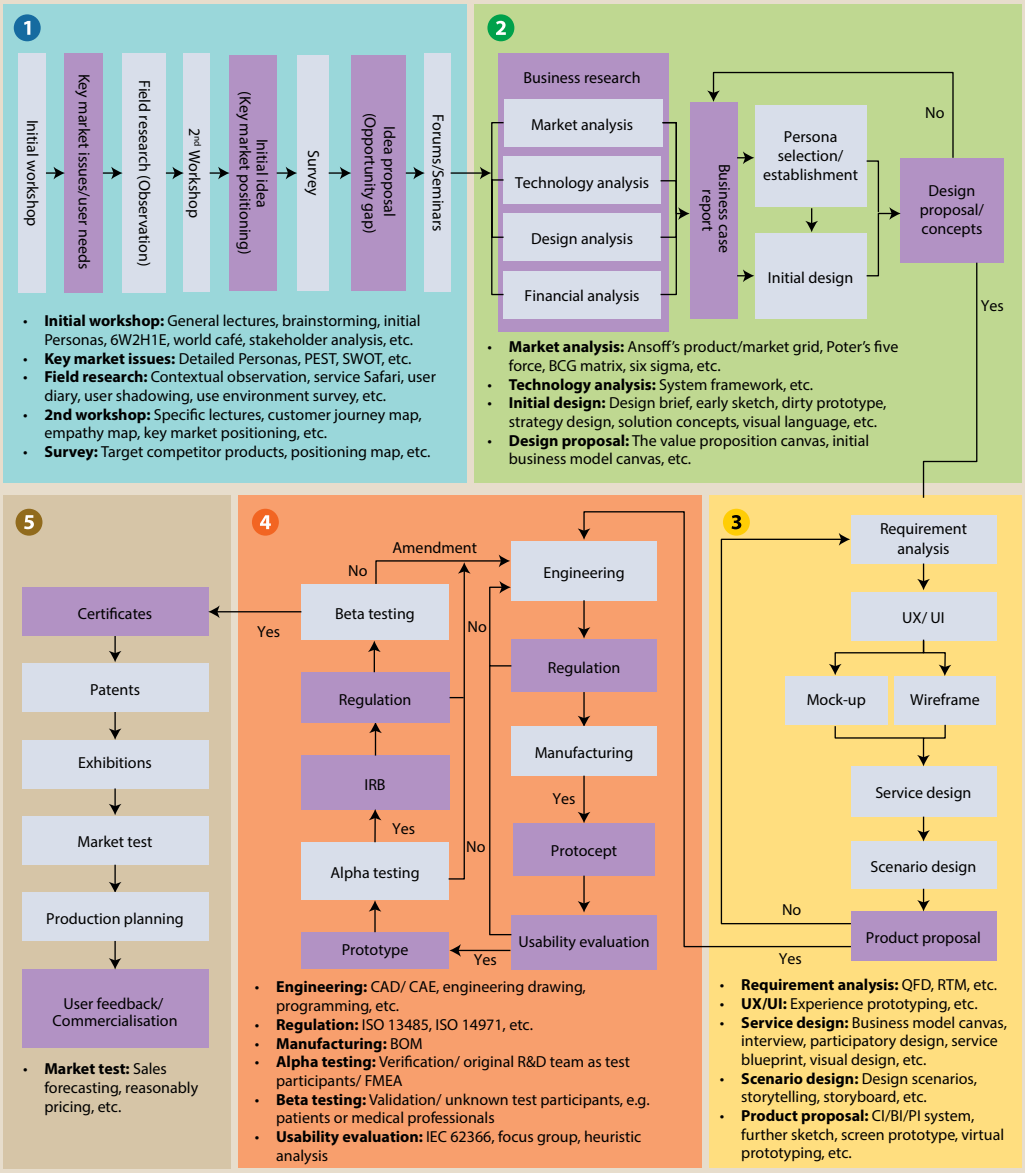
target audience to lead to better products, systems, services, and internal processes. Systems design defines the architecture, modules, interfaces, or data to meet specified requirements. Systems theory can thus be applied to product development.

The IPDD Approach

Figure 3 outlines three critical phases of the human-centered design method for developing the proposed IPDD approach. I proposed the IPPD approach in 2013 as a systematic innovation method to assist organizations, especially SMEs in the health industry, in designing and developing new products or services. The IPDD approach includes a five-stage hybrid design process for NPD, referred to as the O5 method (five opportunities approach). The O5 approach involves identifying opportunities (IO), understanding opportunities (UO), conceptualizing opportunities (CO), realizing opportunities (RO), and opportunity commercialization (OC). Through the five-stage design and development of new products, organizations can systematically guide consumer-centric NPD. Moreover, related process management ensures that new products can be created under the established plan and be accepted by consumers, extending the product's life cycle and reducing production and revision costs. Today, the IPDD approach is successfully used in the public and private sectors for service design, NPD, and system development.

FIGURE 3

THE IPDD APPROACH.



1. Identifying opportunities 2. Understanding opportunities 3. Conceptualising opportunities
4. Realising opportunities 5. Opportunity commercialisation

Source: Reproduced with permission from Tseng [7].

IMPLEMENTING DESIGN INNOVATION

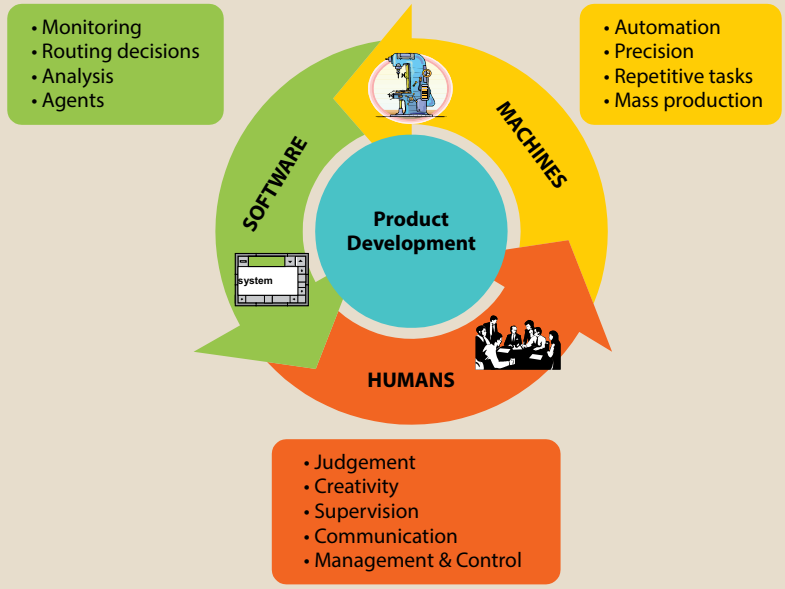
IPDD

NPD requires R&D professionals to share information and arrange design tasks and resources. In a large, complex NPD project, design innovation often involves multiple persons or teams collaborating in the process. Each NPD project carries its goals or mission, thus creating an orientation for arranging suitable R&D professionals to execute design innovation activities. Each R&D professional performs different tasks and requires further design innovation information. The NPD team comprises personnel from various functional departments to support the analysis, design, development, and transition to manufacture a new product. The team provides mechanisms to facilitate the fundamental administration, marketing, design, and manufacturing processes. By involving all the multidisciplinary experts needed during product development, a successful product development team will result in an overall understanding of all the requirements, such as customer needs, the limitations of machine capabilities, more balanced discussion of issues, and alternatives in designing both the product and its processes.

A typical product development environment, as shown in Figure 4, includes humans, machines, and software. An essential condition in a fully integrated distributed process is that all components must be networked and interoperated. Therefore, for distributed product development, the primary requirement is the networkability of all facilities to enable remote working. Most modern manufacturing facilities possess some network interfaces to allow distributed operation. However, for practical reasons, total networking may not always be possible. In a typical manufacturing organization, many nonnetworked facilities may lack such interfaces and therefore cannot communicate directly with the rest of the networked environment.

FIGURE 4

TYPICAL PRODUCT DEVELOPMENT ENVIRONMENT.

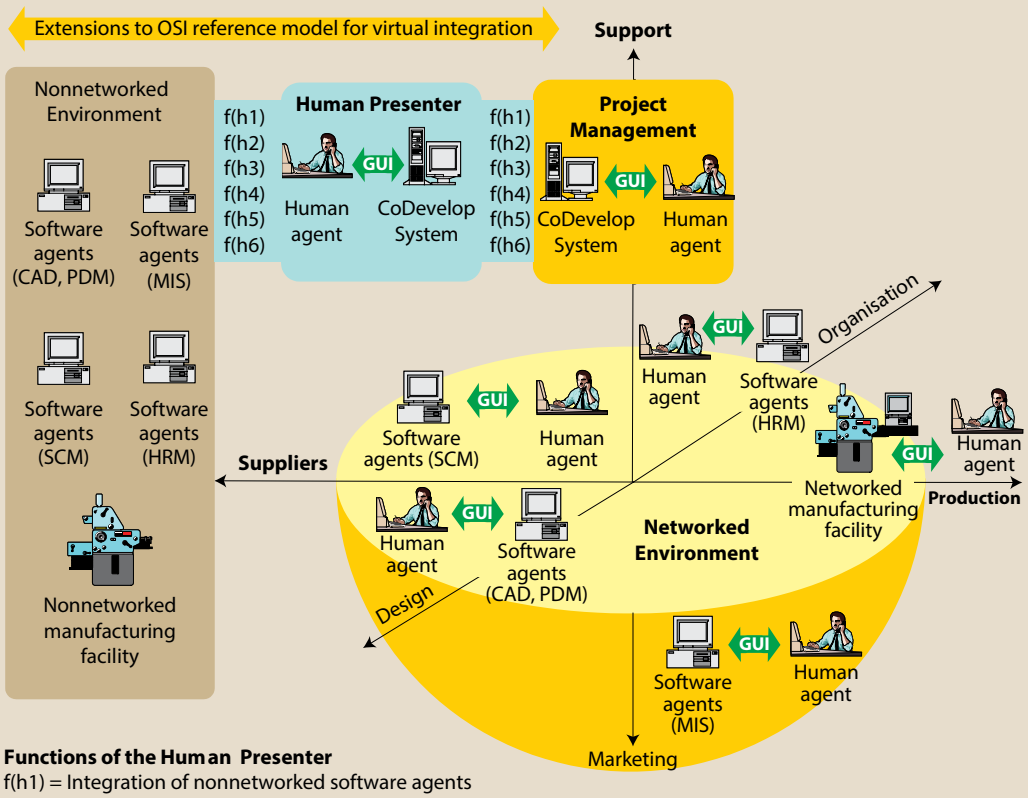


Source: Reproduced with permission from Tseng and Abdalla [8].

The open systems interconnection (OSI) model (ISO 7498:1995) ensures interoperability through a layered architecture. Each layer represents a different level of abstraction ranging from low-level electrical signals to high-level semantics. Figure 5 shows a virtual integration for collaborative product development and how the components of the developed system were configured in the proposed environment. It is assumed that the software agents (such as MIS, HRM, CAD, etc.) are in a nonnetworked environment. The nonnetworked software agents have difficulties in sharing information and data at the presentation layer. However, without an integrated network environment, the nonnetworked software agents cannot take advantage of any application protocols in the presentation layer to ensure distributed collaboration with other agents. Therefore, being in a nonnetworked environment, the software agents cannot take advantage of the distributed collaboration features offered by layer 3 and above. Through the human presenter, the developed system interconnects the gap between a networked environment and a nonnetworked environment to simulate the application protocols of the presentation layer to provide a virtual network interface.

FIGURE 5

VIRTUAL INTEGRATION FOR COLLABORATIVE PRODUCT DEVELOPMENT.



Functions of the Human Presenter
f(h1) = Integration of nonnetworked software agents
f(h2) = Re-using existing facilities and resources
f(h3) = Conversion of non-sharing information at various stages of product development
f(h4) = Provision of data- and functional- interoperability
f(h5) = Support of the project process and operation
f(h6) = Communication and negotiation

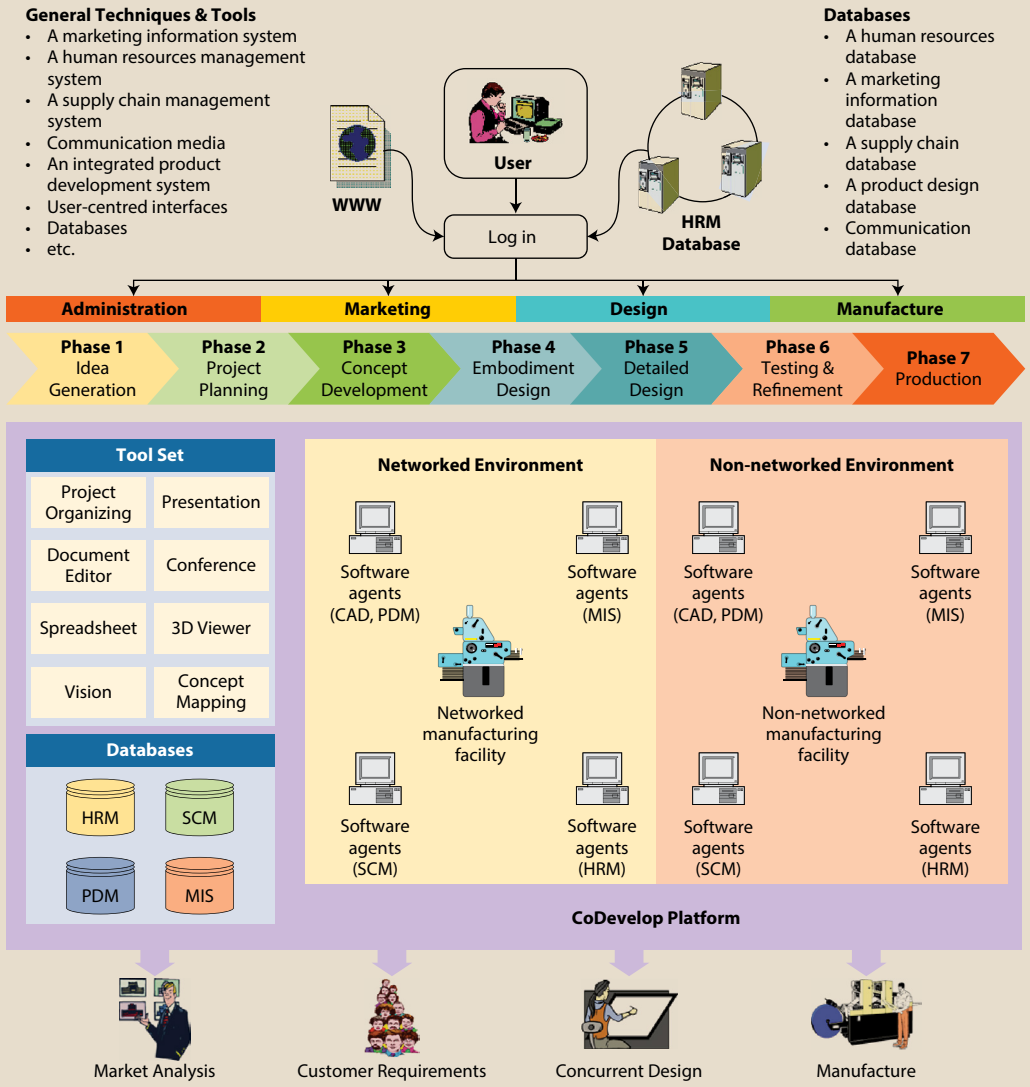
Source: Reproduced with permission from Tseng and Abdalla [8].

As shown in Figure 6, Tseng and Abdalla [8] proposed the CoDevelop platform that includes the processes of project planning and management, idea-generating procedures, marketing analysis, and integration implementation. The users can implement the entire integrated system or operate the individual subsystems separately. In addition, all these systems and databases connect and interact with one another, sharing information necessary according to user requirements. It provides R&D professionals with elastic access to any level of

the NPD process based on their authority. One of the advantageous features of the platform is that it can assist design innovation by integrating NPD stages from idea generation to concept development.

FIGURE 6

OVERALL ARCHITECTURE OF THE CODEVELOP PLATFORM.



Source: Reproduced with permission from Tseng and Abdalla [8].

Technological Innovation for Higher Productivity

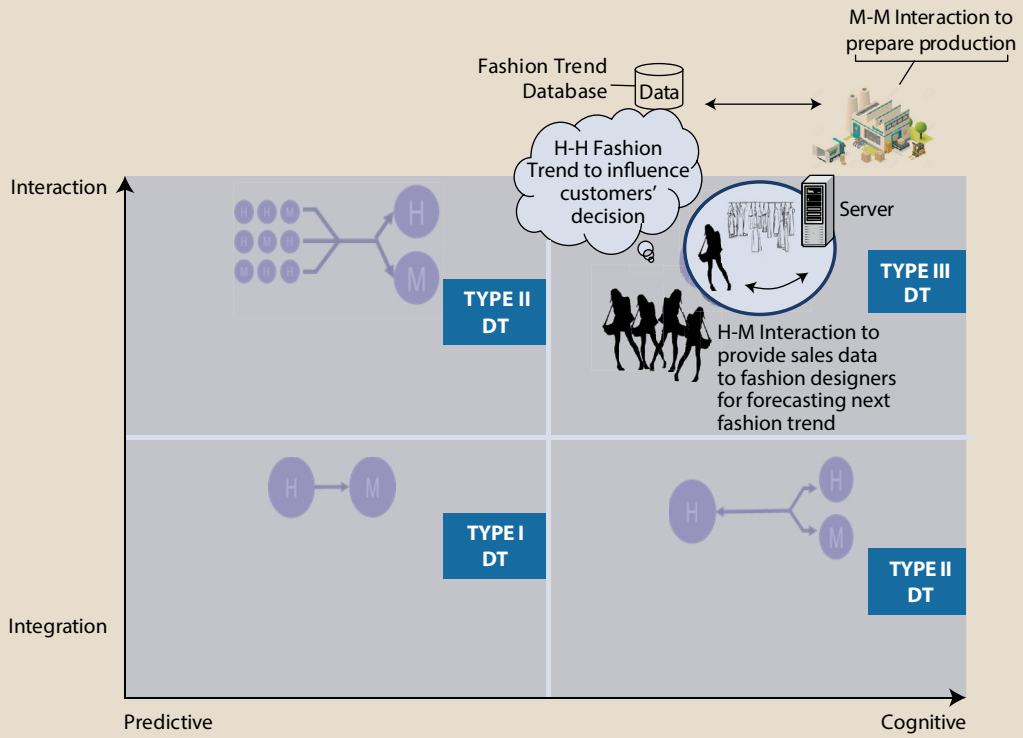
Rapid progress in technological innovation such as the Internet of Service (IoS), Internet of Things (IoT), digital twinning, robotics, cloud computing, and artificial intelligence (AI) has brought the inevitable digital transformation to the design innovation process and helped create innovative products and services. Makridakis [9] pointed out that digital technology and AI will change future production and affect design innovation. Schwab [10] also stated that the era of the Fourth Industrial Revolution has arrived. In the Fourth Industrial Revolution, digital transformation is driven by technological innovation and system integration that will change everything. New partnerships and design innovation processes are being created for the collaboration between R&D professionals and robots, while more advanced applications of AI are being developed [11].

Future design innovation patterns will likely transform into a project-oriented human and AI (HI+AI) collaboration. Commerce will gradually shift from the typical business-to-consumer (B2C) model to a consumer-to-business (C2B) model. Moreover, the barrier between the manufacturing side and the client side will be removed, so that supply and demand can balance, creating a new HI+AI service mode [9].

As advanced technologies enable distributed collaboration and AI decision-making, the future design innovation process patterns will offer significant competitive advantages for many industrial organizations. A digital twin is a dynamic representation of a real-world physical object in the digital world. Digital twinning, through the analysis of physical objects, sensor data, and maintenance methods, creates digital models to interpret, interact with, and integrate the status of physical objects. The digital twin offers a significant way to create and enhance physical asset, process, and service economic values through analyses, monitoring, control, simulation, prediction, and recommendation. Overall, there are three types of digital twin interaction (Figure 7) as they evolve together, known as the digital thread.

FIGURE 7

THREE TYPES OF DIGITAL TWIN.



Source: Produced by the author.

CONCLUSION

Design innovation helps organizations develop innovative products and services and enables increased innovativeness by thinking holistically about design throughout various stages. This article is a summary of how to use design innovation as a strategy for higher productivity. Three critical elements and a design innovation approach are introduced for helping organizations to conduct the design innovation process. With rapid developments in today's society, technology, and economy, digital transformation will occur in all business domains in the future, considering all perspectives of organizational innovation and how design innovation can be conducted. It is essential for businesses to develop an AI strategy for guiding its operations partially or entirely. Moreover, developing HI+AI innovative design business models can help cope with ever-changing customer needs in the future and simultaneously increase organizational innovation capacity and productivity.

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LIST OF FIGURES