

Research on the Trends of Design Knowledge Service Platform Based on Visualized Mapping

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Abstract. To better understand the internal logic of design knowledge and the development context and trend of service platforms, it is essential to sort out and review the literature on related topics. Based on the Web of Science database, this paper selects the literature related to design knowledge and service platforms from 2000 to 2021 as the research sample and combines CiteSpace and VOSviewer knowledge graph software to conduct a visual analysis of the literature data. The results show that : (1) The research on design knowledge service platforms (DKSP) started late, but with the development of science and technology in recent years, the attention of all academic community to DKSP gradually increases; (2) The DKSP belongs to an interdisciplinary research, involving computer, economy, management, education, art, and other fields; (3) The development of DKSP is closely related to information technology. The application of new technology and the demand for popularization make it gradually embark on the road of social media and commercialization. (4) An interactive knowledge platform network is the future of DKSP, with the goal of multi-participant co-creation, platform knowledge sharing, and multi-value symbiosis.

Keywords. knowledge mapping, design knowledge, service platform, design knowledge service platforms(DKSP)

1. Introduction

After experiencing the industrial revolution of large-scale mass production, the global economy and society are gradually transforming to the era of decentralized knowledge economy characterized by network services. Accordingly, the paradigm and boundary of design discipline are also changing. Design is essentially a process of knowledge flow, integration, competition and evolution [1]. Design research is equivalent to the production of design knowledge. A great deal of new knowledge is created in research, so that the boundaries of the design discipline are constantly being expanded [2]. In the current era of the global knowledge economy, which is comprised of increasingly integrated cross-border distributed knowledge and learning systems [3], design knowledge must rely more heavily on the service mode of digital platforms to achieve the desired outcomes of benign dissemination, sharing, and sustainable circulation. As a mainstream form of information service, the DKSP uses information processing

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technology to extract the content people need from various explicit and implicit design knowledge resources, so as to achieve the effect of knowledge dissemination. DKSPs have diverse forms, such as literature-sharing websites, design-based video-sharing platforms, design material repositories, design enthusiast exchange platforms, etc. The development of knowledge service platforms is a symbol of the progress of the times and is also an inescapable research theme in the development of the design discipline.

The findings of a search of the Web of Science literature database indicate that the design community discusses the DKSP infrequently, with the majority of literature disciplines coming from computer science, management, economics, and education. Despite the fact that the differentiation of discipline attributes will bring more cross-perspectives to the topic, the research focus is different. Therefore, it is essential to explore and discover the future research frontier of DKSP from the perspective of design discipline in the historical development process [4]. This paper aims to apply visualized mapping and the scientific measurement method, respectively, to the design knowledge and knowledge service platform for the quantitative analysis of literature. This paper explores the current status, progress, and trends of research on foreign DKSPs by generating a mapping of the number of articles issued, keyword co-occurrence, and keyword emergence, aims to providing valuable conclusion and insights for references.

2. Explicit transformation of design knowledge

In the age of Industry 4.0, the emergence of new digital technologies such as artificial intelligence and big data prevents the overly segmented and segregated disciplinary. The community is tendency to tackle the increasing complexity of design science research with interdisciplinary and integrated approaches. There is now a general awareness in the design community that experience in solving traditional design problems is no longer appropriate for areas such as transformational design or service design. The scope of design activity has gradually expanded from the tangible world to the larger intangible world [2]. The changing environment in which the design discipline operates also requires the appropriate updating and iteration of previous design methods and tools. Obviously, the newly transformed design techniques, such as collaborative design and participatory design, are all used in practice based on the virtuous cycle of the design knowledge of all participants, which highlights the significance of knowledge sharing and dissemination.

Paul Gardien, the former director of the Philips Global Design Center, divided the economic paradigm behind design into an industrial economy, an experience economy, a knowledge economy, and a transformation economy [5]. He argues that humanity is in the midst of a wave of change in the global knowledge economy, a view that has much in common with the design 3.0 perspective proposed by academician Lu Yongxiang[6]. Both of them believe that the discipline of design has broken away from the traditional monolithic knowledge structure represented by product design and has gradually transformed into an interdisciplinary knowledge structure represented by the integration of design ecosystems or platforms. This mode of producing design knowledge is consistent with Michael Gibbons' theory of mode 2 [7]. Bertola et al. classify the participants in design activities as knowledge agents, knowledge integrators, and knowledge intermediaries [8]. Mazzotta argues that the design field has transitioned from an action-based to a knowledge-based paradigm. Cai believes that the

design knowledge system has been modified as a mode of knowledge production and applied to the interdisciplinary design field [2]. According to Zhu et al., the value-added information and knowledge elements in the design process will become the key competitive factor of a new product [9]. This academic literature emphasizes on the significance of design knowledge and the urgency of its better and more rapid dissemination.

Design knowledge consists primarily of tacit knowledge, which includes the intangible skills, judgments, and intuitions possessed by human experts, as well as the insights, inspirations, visual feelings, and experiences of individual designers. This knowledge is subjective, arbitrary, and nebulous [10-11]. There still exists a communication barrier to the sharing of knowledge. The advent of the knowledge economy and the Industry 4.0 era has built a better environment for the explicit transformation and dissemination of design knowledge. Design knowledge can be shared with expert service platforms. The social and digital nature of the service platforms creates good conditions for the development of design as a 'brain-intensive' discipline, transforming design knowledge into the knowledge network service model of the future. This paper attempts to examine the development context and trend of the DKSP in an effort to gain a comprehensive understanding of this subject. The goal is to improve the transformation of design knowledge from tacit to explicit and to increase its dissemination and reusability via the platform. This paper explores the internal logical framework of its development [12] to gain a better understanding of the DKSP's future research possibility.

3. Retrospective experimental study: the development of design knowledge

This paper uses the Web of Science's core collection as its database, design knowledge as its research topic, CiteSpace citation space software (version 6.1.R2) as its primary research tool, and VOSviewer software to assist the research and evaluate the results. "Design Knowledge" was used as the search term and the following search formula was used: TS= (" Design Knowledge* "). The search period was limited to Jan. 1, 2000 - Dec. 31, 2021; 315,345 pieces of literature were determined, including those pertaining to computer science, management, medicine, and agriculture. Then, according to Xu Jiang's comprehensive results of domestic and foreign scholars in journal texts [13]. This research removed the journals of related subject literature that are not included in the WOS core collection and combined them with experts' judgment, selecting 24 international journals as data sources (Table 1). Finally, 2,969 literature articles were retrieved. This paper uses the software above to draw and analyze the knowledge graph of the target literature's number of publications, keyword co-occurrence network, and emergent network.

Table 1. Data sources for designing research journals.

Order	Journal Catalog	Order	Journal Catalog
01	Applied Ergonomics	13	Journal on Multimodal User Interfaces
02	Creativity and Innovation Management	14	Personal and Ubiquitous Computing
03	Design Issues	15	Research in Engineering Design
04	Design Studies	16	Visual Communication

05	Ergonomics	17	International Journal of Industrial Ergonomics
06	Human Factors	18	Behaviour & Information Technology
07	Interacting with Computers	19	Design Journal
08	International Journal of Design	20	Information Visualization
09	International Journal of Technology and Design Education	21	Huamn-Computer Interaction
10	Journal of Engineering Design	22	International Journal of Human-Computer Studies
11	Journal of Mechanical Design	23	Journal of Knowledge Management
12	Journal of Product Innovation Management	24	International Conference on Engineering design

According to the data retrieval results, firstly, the co-occurrence and clustering of keywords in the target literature was analyzed. This type of research reveals the affinity relationship between multiple groups of words by analyzing their co-occurrence times in the same literature to perform hierarchical clustering on these words to analyze the changes in the topic structure they represent [14]. Finally, it obtains the keyword co-occurrence map of "design knowledge" (Fig. 1).

As the figure depicted, based on literature keywords frequency and discipline characteristics, the results can be roughly divided into three clusters (distinguished by three colors): design knowledge, knowledge sharing, and knowledge management as the respective central nodes. The graph clustering method is utilized for network clustering. Five major knowledge groups are generated directly by knowledge graph software: knowledge management, knowledge, design knowledge, knowledge sharing, big data, and community of practice.

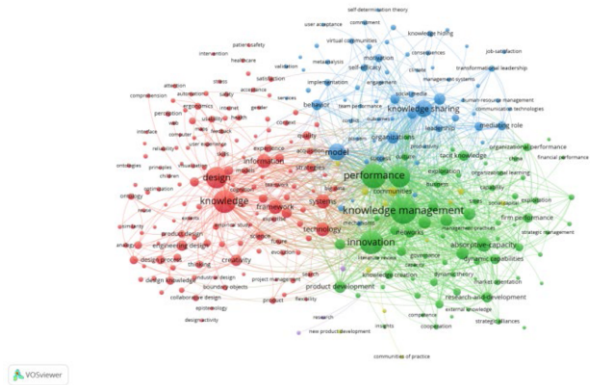


Figure 1. Keyword co-occurrence mapping of "design knowledge".

The results of keyword co-occurrence clustering indicate that the research hotspots from 2000 to 2004 were primarily in knowledge management, knowledge, and design knowledge, with the following high-frequency terms: design, organization, system, communication, behavior, decision making, etc. From 2007 to 2012, the research hotspots focused primarily on knowledge management, design knowledge, and knowledge sharing, with network, community, design thinking, and firm as the most frequently occurring terms. After 2012, however, the research hotspots began to diverge gradually, although the divergence direction of the five knowledge groups was relatively similar. The respective time evolution track contained keywords such as business, economics, efficiency, security, computer interaction, member knowledge

exchange, online communication, organizational innovation, enterprise, tools, team, and so on. With the advancement of science and technology, it is evident that research on design knowledge is shifting from knowledge ontology to knowledge application and spreading through online platforms and social networks. The emergence of keywords like business, economics, and organizational innovation suggests that commercialization may be a future development direction for design knowledge.

CiteSpace V is utilized to detect the keyword emergence of imported literature data, to unearth concepts with obvious short-term word frequency changes in the literature, and to generate the keyword emergence diagram (Fig. 2). These high-frequency burst concepts frequently represent research frontiers and hot spots in different periods. These concepts also have the sensitivity, burst, and dynamic advantages of revealing new research topics on intersections [15]. According to the keyword emergence diagram, from the research on "knowledge" in the year 2000 to the research on "knowledge management" and "knowledge sharing" in the year 2010, the research on "knowledge hiding" and "external knowledge" will become more in-depth and specific by the year 2020. From early research on the concept of "design" to today's focus on "product innovation" and "mechanism," this paper demonstrates that design knowledge is gradually refined and materialized, and rapidly transformed into specific products, platforms, and service systems. From the prior discussion of "information" and "acquisition" to the current transformation of "firm performance" and "transformational leadership." This transformation reflects that design knowledge is gradually breaking through the knowledge barriers, rapidly integrating with the commercialized economy, and continuously promoting the development of global design knowledge networks.

Top 25 Keywords with the Strongest Citation Bursts



Figure 2. Keyword emergence map of "design knowledge".

Through the preceding analysis, it is evident that design knowledge is constantly breaking through disciplinary boundaries, incorporating knowledge from other fields, transforming to the goal of socialization and commercialization, and exhibiting and spreading in increasingly diverse forms as science and technology advance. System and platform play a crucial role in this procedure. Diverse platform types, such as social and educational platforms, facilitate the dissemination of design knowledge. As research on design knowledge has increased, the DKSP has gradually attracted the

interest of individuals from all walks of life. Therefore, in this era of knowledge competition, reflection and review of the subject are essential to create better dissemination channels for design knowledge is the key to enhancing the competitiveness of countries, companies, and products. At the same time, there is a theoretical value of an in-depth understanding of the historical processes, patterns, or trends of DKSPs through a data mapping-style disciplinary overview.

4. Foresight Experiment: Evolution of Design Knowledge Service Platform

The research on the topic of "Design Knowledge Service Platform" also uses the Web of Science Core Collection as its database. The search form is TS= (" A service platform for Design knowledge* "or" A platform for Sharing Design Knowledge * "and" Dissemination of Design knowledge* "). The search time range was limited from January 1, 2000 to December 31, 2021. It screened the literature type and research direction of medicine, agriculture, biology, chemistry, and other unrelated discipline options, for a total of 1298 literature data points. Finally, it uses CiteSpace and VOSviewer software to draw and analyze the knowledge graph.

According to Figure 3, research on the "design knowledge service platform" is still in its infancy, but the overall trend indicates a steady upward trajectory. The study expanded from a minimum increase of just two articles in its early stages to a maximum increase of twenty-eight articles in 2019. This demonstrates that in recent years, design academia has paid a growing amount of attention to this topic and that it has become an area of intense interdisciplinary research.

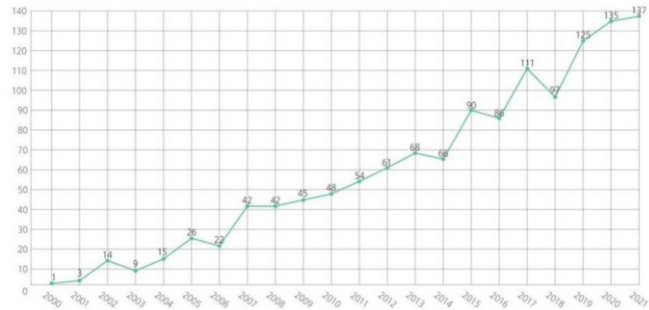


Figure 3. Statistics on the number of articles posted on the topic of DKSP.

Based on the additional data retrieval outcomes, the following keyword clustering timeline map (Fig. 4) and eight knowledge group classifications can be derived. As shown in the figure, research on "design knowledge service platform" around the year 2000 focuses primarily on "co-production" and "model" and primarily discusses the general theory underlying the system construction of knowledge service platforms. Since 2004, researchers have gradually shifted their attention to knowledge management, digital transformation, and the Internet of things. The research from 2004 to 2010 focuses on four aspects: knowledge hierarchy management, platform prototyping, investment in emerging technologies, and commercial application. However, after 2010, the research hotspots diverged once more, and "Big Data" and "social media" were added to the original hotspots. Until approximately 2020, this topic will primarily be discussed in terms of social media, digital communication, digital

platforms, information exchange, product innovation, information service, and cloud platforms. This research has established three major trends: the transformation of business media, the application of science and technology, and knowledge network service.

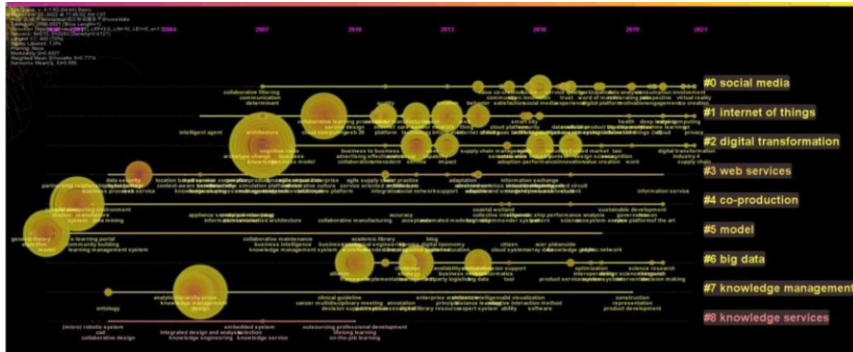


Figure 4. Temporal mapping of keyword clustering.

In this study, VOSviewer was used to import literature data and generate the keyword co-occurrence time map (Fig. 5). The map is performed by calculating the score based on the average year in which keywords appear. The color level is divided by the time dimension, which progresses in the time development order of purple (2014), blue (2016), green (2018), and yellow (2020). As illustrated in the figure, early research on the topic of "designing knowledge service platforms" focuses primarily on platform architecture, model, and Internet technology applications. In recent years, a greater emphasis has been placed on the social media properties of service platforms, the principles of value co-creation and open innovation, user behavioral motivation and sensory analysis, the digital dissemination of design knowledge, and the application of emerging technologies like artificial intelligence. On average, two software export "keywords co-occurrence time map" and "clustering time map" of the overall development trend are consistent. The platform of the underlying framework from the early research development gradually to the exploration of platform value, pattern innovation, and platform value. Its development trend is mainly oriented toward media, platform technology, and knowledge networks, three big modules. From the background of the knowledge economy, this may be the focus of the discipline's research in the next few years.

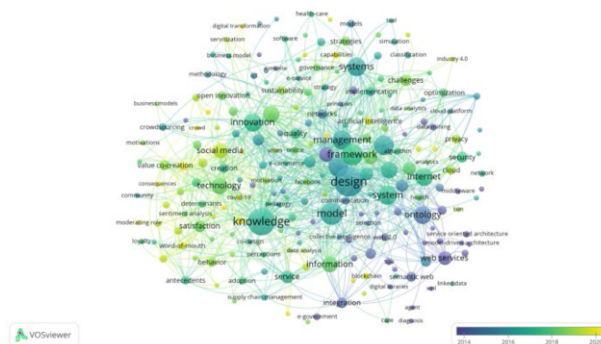


Figure 5. Temporal mapping of keyword co-occurrence.

During the retrieval of subject literature, this paper discovered through data that computer science accounted for the largest proportion of literature obtained, followed by economics, management, education, and other disciplines. This indicates that interdisciplinary research is being conducted on the DKSP's theme. In order to draw relatively objective conclusions from this data, it is necessary to compare and analyze it from multiple perspectives, disciplines, and angles.

In order to gain a deeper understanding of the research and disciplinary trends surrounding the topic of "design knowledge service platform", the subject literature was divided into "Engineering & Computer Science," "Business, Economics & Management," and "Humanities" according to the subject classification Directory of Google Scholar. CiteSpace was utilized for keyword outburst analysis and cross-comparison in this study, while VOSviewer was utilized for result inspection. Finally, a research phase diagram of key disciplines for the design of a knowledge service platform was created (Fig. 6). As depicted in the figure, the research on the DKSP of these three key disciplines all began with the construction of the discipline system from a series of knowledge elements. Nonetheless, with the rapid advancement of science and technology and the intensification of people's research on knowledge platforms, the knowledge of various disciplines is becoming increasingly interconnected and interwoven. After these subjects from previous distributed ontology research gradually entered the same orbit, people began to discuss the creative methods in the DKSP, business model, user behavior, and factors such as the value of sharing. This pushed them towards a more comprehensive and integrated research direction, thereby accelerating the evolution of the knowledge economy through the continuous expansion of the boundary between design disciplines.

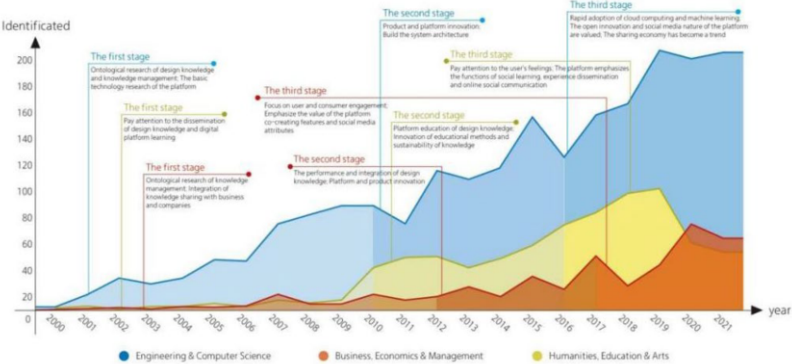


Figure 6. Research stages of key disciplines of the DKSP.

5. Development trends of design knowledge service platform from the perspective of knowledge mapping

Through research involving retrospective experimentation and predictive experimentation, three trends of DKSP have been identified.

- DKSP are gradually becoming commercialized, socialized, and media-oriented.

With the deepening research of design disciplines and the rapid development of the experience economy, people's demand for design knowledge keeps increasing. As one of the mainstream forms of knowledge dissemination, DKSP have created convenient conditions for the explicit transformation of design knowledge. Design knowledge is made more widely available and applied through the power of service platforms. In an era where everyone is a designer, there is more demand than ever for research into DKSP. The increase in social demand is driving DKSP to gradually embark on the path of social media and commercialization. The commercialization of DKSP can lead to further innovation and application of design knowledge, thus bringing more core competencies to countries, companies and products.

- The advancement of science and technology increases the diversity of platforms for disseminating knowledge.

Scientific and technological factors are integral to both design knowledge and DKSP. In the era of Industry 4.0, The rapid application of new technologies such as artificial intelligence, the Internet of Things and big data computing has created more opportunities for the dissemination of design knowledge. The emergence of new features such as voice recognition and platform co-working has reduced the cost of receiving and learning knowledge for users. The progress of modern science and technology is accelerating. Future applications of VR, AR, digital twin, and other technologies will further facilitate the transformation and dissemination of design knowledge. Smart technologies will be deeply involved in the development and optimization of DKSPs.

- The transition from a personal knowledge management platform to an interactive networked knowledge platform.

In the early days of information technology development, it cost the general public a lot in learning how to build a personal knowledge platform. With the popularity in application of the Internet, user needs for design knowledge management are gradually increasing. The expansion of market demand has led to the gradual popularization, socialization and commercialization of interactive knowledge service platforms. With the advent of Web 3.0, demand has increased for decentralized knowledge network services. The DKSP relies on the second-generation knowledge management model to bridge knowledge acquisition between billions of knowledge participants. The DKSP uses digital technology to realize the creation and transfer of design knowledge between individuals, organizations and outside organizations, forming an interactive knowledge platform network. The management mode of the knowledge platform network transforms the former design knowledge silos into an interconnected and distributed knowledge platform continent. The DKSP network will be an important force in realizing the beautiful vision of participant co-creation, platform knowledge sharing and multiple values co-production.

6. Conclusion

In the era of the global knowledge network, a significant portion of the economic wealth of developed economies is derived from the creation, development, and dissemination of knowledge and information [16]. The construction of the knowledge service platform has built convenient conditions for the dissemination and distribution of design knowledge. The DKSP takes advantage of digitalization and information

technology to enable design knowledge to be explicitly transformed and widely applied. Design knowledge is better involved in product design and service innovation by relying on the power of the platform. This paper uses a data mapping approach to provide insights into the historical process and development trends of DKSP. An in-depth exploration of the topic is a benign reflection on design research in its developing process, and such research has academic value for the future exploration of DKSP.

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