

Article

Analysis of Domain Intersection and Knowledge Evolution—The Development of the Fields of Social Innovation and Design Education

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Abstract: This paper synthesizes the literature from the fields of design education and social innovation to obtain a complete understanding of the development of these fields' knowledge, and it also compares and cross-analyzes the two fields to determine the entry point for combining the knowledge in both fields. Two types of bibliometric software were used to capture and classify the data, and descriptive statistical analysis, co-occurrence analysis of keywords, knowledge evolution analysis of studies cited in both fields, and burst analysis were conducted. The results reveal that integrating technology into the field of design education in combination with shifting the focus from enhancing students' professional competence to enhancing their overall competence can contribute to the improvement of design education quality. This is in the context of empathy research becoming a trend. Furthermore, the field of social innovation defines "social innovation" as a mutual agreement between practice and theory to promote solutions to society's problems. The research in this field covers all aspects of social life and has a complex disciplinary background. The field of social innovation is currently mostly concerned with the relationship between universities and social innovation practices. The burst analysis reveals that open innovation is becoming a common focus of both fields and is developing into a popular research topic.



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Keywords: social innovation; design education; knowledge evolution; domain convergence; bibliometrics

1. Introduction

Time to Change Design Education [1]. The current technological system is facing transformation, with significant social needs and challenges constantly emerging. It is an era in which everyone participates in design. It requires us to collectively reconsider the role of design and designers in today's society, as well as new knowledge and skills. Preparation should be made for constructing a sustainable, flexible social culture and a new civilization [2]. Today, intelligent devices, the Internet of Things, virtual reality, 5G networks, artificial intelligence (AI), and other technologies are widely applied. The soundness and improvement of urban public cultural facilities; the extensive construction of urban commercial complexes; the rapid development of social media; the rise of cultural and artistic activities—these are all products of "social innovation" [3]. In the context of social innovation, design education is undergoing numerous transformations and challenges. Designers need to focus on organizational structures and social issues [1]. Integrated with technological changes, social transformations, and international competition, design education tends towards meeting social needs, revolving around the cultivation of innovative talents for national strategies and industrial development [4].

We aim to seek new pathways for design education in future social development and establish effective ways for design education to serve society using the relatively comprehensive Web of Science database as the source of analysis. We also considered a

bibliometric study on design education and social innovation. This study aims to seek new pathways for design education in future social development and establish effective ways for design education to serve society. The Web of Science database is used as the primary source for analysis. Citespace 6.1.R6 and Vosviewer 1.6.18, representative bibliometric software, are utilized to capture valid knowledge. Relevant research literature on the themes of “design education” and “social innovation” is systematically obtained. Through the perspective of bibliometric research, this study conducts an in-depth investigation into the disciplinary background, representative figures, representative institutions, knowledge evolution, integration keys, and future research directions behind design education and social innovation. The characteristics of development, development paths, and development scale of design education and social innovation since their inception are clearly presented to find a logical and mutually beneficial pathway for their integration. This study provides a theoretical basis for promoting the extension of design education to society and support for social innovation.

One of the distinctive signs of many countries entering the era of post-industrial society is the predominance of theoretical knowledge and self-aware research being conducted to advance theoretical knowledge and solve problems. As George Fallis states in “The Mission of the University”, due to the export of knowledge, universities are starting to become the main institutions of post-industrial societies: “The university is one of the main innovative forces in society, one of the main determinants of social opportunity and social stratification, the focal point of intellectual and cultural life” [5]. At the same time, design education in universities has an important educational and social mission, exemplifying universities’ efforts to enact their social role. Therefore, the ways in which design education can balance imparting professional knowledge with the assumption of social responsibility in universities needs to be determined. This is a question many university design educators have asked. Along with the rapid spread of knowledge interoperability in university education, social innovation is a new concept of social practice that aims to meet social needs and solve social problems [6]. It has also allowed for the beneficial integration of many disciplines, such as sociology, political science, management, and many other humanities and social sciences, thereby offering a new perspective for solving the research problems in these disciplines. Therefore, the research questions for this paper are as follows: (1) How can design education and social innovation be combined, and what perspectives can be used for this purpose? (2) How is the field of design education developing in relation to social innovation? and (3) What is universities’ role in the study of social innovation? In order to answer these questions and to facilitate future research, this paper uses the literature from the design education and social innovation fields as an information source as well as bibliometric software to search for and summarize important information contained in these data. The information relevant to the questions is then summarized and analyzed to determine the mediating roles of the two fields from an interdisciplinary perspective, thus identifying the latest research directions in these fields. The references involved in the study primarily focus on analyzing the intersection of the fields of social innovation and design education. Key thematic clusters include motivation, self-efficacy, integration, higher education, design thinking, communication, and case studies. Relevant literature has been extracted regarding the four developmental stages in the individual domains of design education and social innovation, as well as their intersection.

This study was designed according to the intersection of disciplinary knowledge, with the evolution of disciplinary knowledge comprising the overall research plan. The rest of the paper is structured as follows: The second part of the experimental design plans the databases and search methods for the research sources, as well as the de-duplication and time setting of the literature data. Finally, it explicates how this study is divided into separate sections: (1) a disciplinary knowledge intersection analysis, comprising a co-occurrence analysis of the keywords in the domains and a co-occurrence analysis of the terms that are strongly related, which are used to obtain information from the two fields that is strongly related to each other and to propose the entry point for combining this

knowledge; (2) a knowledge evolution analysis of the studies in both fields, comprising co-citation analyses of design education and social innovation literature, which are used to determine the two fields' knowledge evolution processes (see Figure 1); and (3) a burst analysis, which is used to explore future research directions. The Section 3 presents the results for each field. The Section 4 then details the current research and knowledge base for both fields, followed by the Section 5, which delineates the future research avenues. Lastly, the Sections 6 and 7 comprise the discussion and the conclusion, respectively.

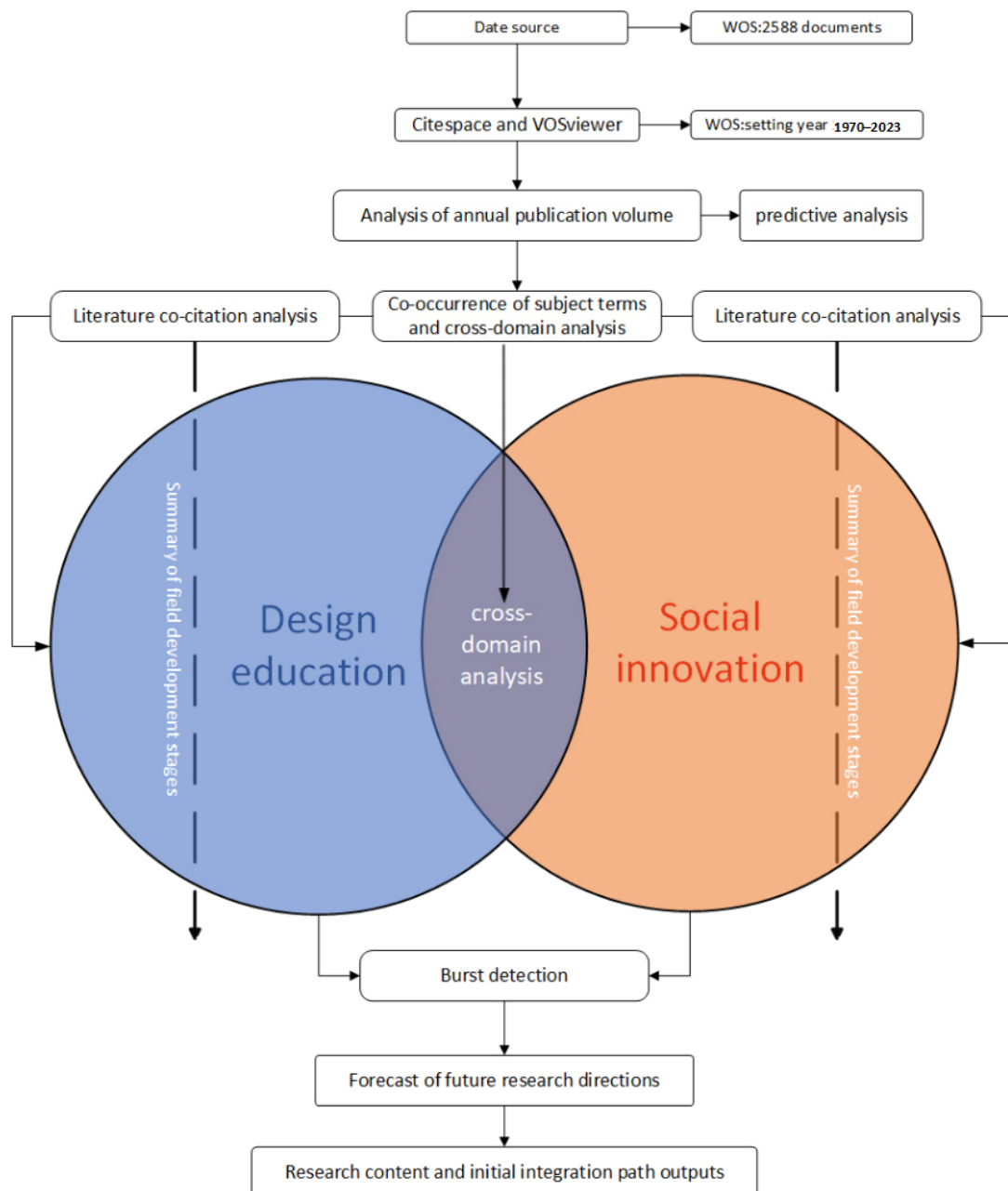


Figure 1. The technology roadmap.

2. Experimental Design and Experimental Procedure

2.1. Experimental Design

The current research on design education and social innovation was analyzed using Citespace and VOSviewer data analysis software. This entailed searching the keywords “social innovation” and “design education” on the Web of Science (WOS) database in the

Science Citation Index (SCI) and Social Science Citation Index (SSCI). The themes were derived from the components identified in the literature, including the keywords used by the relevant authors, countries, institutions, references, and the like. This large body of literature was then analyzed to obtain a comprehensive understanding of the current research in the field.

2.1.1. Data Sources

For international research, the data were collected by searching the keywords “design education” and “social innovation” in the SCI and SSCI of the WOS, from which 2588 documents were obtained. These data, obtained in txt. format, were fed into the data analysis software. Only studies between 1970 and 2023 were included in the sample.

2.1.2. Data Analysis Matching

The study is organized according to its purpose, the themes of analysis, and the bibliometric programs’ capabilities. Citespace was used to analyze the fields’ current research and knowledge bases, as well as to conduct the burst analysis. This analysis comprised a co-citation analysis of the literature, with the literature being identified by the keyword “burst analysis.” Moreover, VOSviewer was used for the co-occurrence analysis of the keywords and the domain cross-tabulation analysis.

2.2. Experimental Procedure

2.2.1. Citespace Analysis

The relevant studies were imported into Citespace for conversion, and they were organized into chronological order. After this, a project entitled “Research in the field of design education and social innovation” was created. The data included the keywords, abstracts, references, institutions, countries, authors, and journals contained in the literature. A literature co-citation analysis was then performed. This software includes the “Unified Links” parameter and the selection criteria. The “Unified “Links” parameter represents the normalization process for the co-occurrence matrix, which is divided into two specific steps: (1) association strength, which corresponds to the association strength of network nodes using a cosine algorithm (see Figure 2 below); and (2) range, which corresponds to the operations performed within the period under investigation. The selection criteria are divided into three default instructions: (1) g-index, which is used to extract knowledge units according to the modified g-index by increasing the scale factor k (default k = 25), which is interpreted as an increase or decrease in the number of visualization nodes; (2) top N, which is the number of objects extracted within each period, with the top 50 being extracted for each study as a default; and (3) topN%, which denotes the number of objects extracted in each time period in percent, with a default of 10. Therefore, this study switched the year setting and node type according to the study content.

$$\text{Cosine}(c_{ij}, s_i, s_j) = \frac{c_{ij}}{\sqrt{s_i s_j}}$$

Figure 2. The cosine algorithm used to determine association strength.

2.2.2. VOSviewer

The data were imported into the VOSviewer data selection field. Then, the “Co-Occurrence” operation was selected, followed by the “All Keywords” and the “Full Counting” operations, which resulted in the co-occurrence network of subject terms.

3. Results and Analysis

3.1. Descriptive Statistical Analysis

The Number of Articles Published Annually

The analysis of the number of publications annually in the field provides a general understanding of the literature's development, thus capturing important stages in the development of the field. Studies published over the last 53 years, from 1970 to 2023, were retrieved from the WOS database (see Figure 3). The research in the WOS database was broadly divided into the 1970–2000 emergence period, the 2001–2014 budding period, the 2015–2020 takeoff period, and the 2021–2023 stabilization period. Only 1 to 9 articles were published in the 1970–2000 emergence period, with an average value of 3.84, which is much lower than the annual average publication rate ($53.92 > 3.84$). During the budding period of 2001–2014, the number of studies published increased steadily: While there was a small decline during this period, there was an overall upward trend. The number of studies published in this phase remained in the double digits, at an average rate of 41.07 ($\text{Ave} < 53.92$). The total number of papers increased from 96 in the previous stage to 575 in this stage, thereby indicating that the concepts relevant to this study were initially established in this phase and were soon practically applied to determine new concepts and content. During the 2015–2020 takeoff period, the number of published studies in this field increased significantly, with a minimum of 123, a maximum of 371, and an average of 205.67 papers ($\text{Ave} > 53.92$). Therefore, this stage resulted in more theoretical and practical research results than in the previous period. According to the theory related to bibliometrics, this upward trend demonstrates that the number of studies published will stabilize at a number that is above the average in the future.

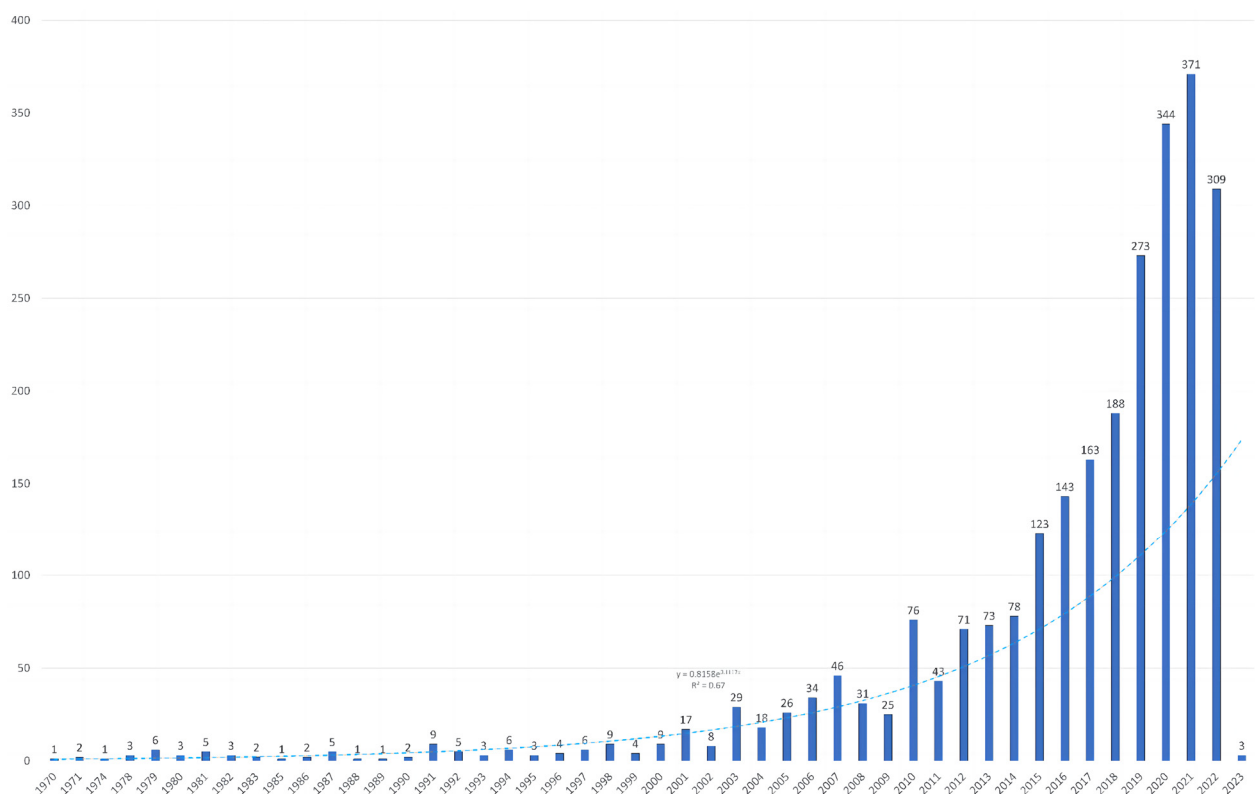


Figure 3. The number of studies published between 1970 and 2023.

3.2. Co-Occurrence Analysis of the Keywords

3.2.1. Co-Occurrence Analysis of the Subject Terms

The categories into which these studies were divided were informed by professional studies on design education and social innovation. Natural language processing was

used to extract and analyze the subject terms of these specialized studies so as to ensure a high level of generalization of the research in these fields. This process included titles, abstracts, and keywords being extracted from the studies, thereby ensuring a large amount of research that was represented by subject terms. This analysis resulted in 8302 topics being identified in the titles and abstracts of 2588 studies on design education and social innovation. Following this, domain terms with frequencies greater than five were screened, and a keyword co-occurrence network was constructed, resulting in 652 topics. The corresponding topic distribution is shown in Figure 4, in which the node and label sizes are proportional to the frequency of the topic terms, with the frequency of the topic terms representing the number of papers on that topic. The resolution of the clusters in the analysis term was set to 0.9 to form five clusters (indicated by red, green, blue, purple, and yellow) that matched the number of clusters. A summative analysis of the top 20 ranked keywords within each group yielded the following research directions for each group (see Table 1): (1) design education research, which focuses on the cross-disciplinary integration of design education, such as design and technology as well as process and manufacturing, in addition to imparting knowledge and inspiring innovation. In addition, collaboration in the student design process is emphasized, with the aim of increasing the standards of design education to improve higher design education. (2) Agroforestry-related social innovation, which is aimed at ensuring the sustainable development of rural and forest environments. Moreover, the breakthroughs made by grassroots innovations were determined by analyzing the current policies, systems, and management methods, after which a new model of social governance was developed using social innovation theory. (3) Social innovation in social organizations, which investigates how third institutions can effectively develop in society and achieve a balance between social value and economic value, thereby ensuring social responsibility. (4) Social innovation in regional issues, which is mostly analyzed from the perspective of social innovation by first examining the various problems that exist. Finally, (5) encompassed cross-disciplinary collaborative social innovation across fields, i.e., collaboration and multi-disciplinary as high-frequency themes, mostly for innovation purposes.

Table 1. The top 20 topic words for each cluster.

Rank	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
1	Design education	Social innovation	Innovation	Sustainable development	Participation
2	Education	Sustainability	Entrepreneurship	Health	Co-creation
3	Creativity	Governance	Impact	Field	Co-production
4	Performance	Management	Social entrepreneurship	Services	Communities
5	Design	Policy	Challenges	Models	Creation
6	Knowledge	Framework	Networks	Adoption	Engagement
7	Model	Systems	Organizations	Gender	Barriers
8	Technology	Politics	Social enterprise	China	Value co-creation
9	Thinking	Resilience	Perspective	Implementation	Open innovation
10	Students	Community	Strategy	Circular economy	Context
11	Science	Cities	Future	Care	Government
12	Collaboration	Transitions	Behavior	Growth	Technological innovation
13	Strategies	Power	Responsibility	Social change	Product development
14	Design process	Economy	Business	Insights	Welfare
15	Engineering design	Dynamics	Enterprise	People	Co-production
16	Design thinking	Transformation	Leadership	Qualitative research	Methodology
17	Work	Institutions	Sector	Quality	Dominant logic
18	Product design	Grass-roots innovations	Poverty	COVID-19	Smart cities
19	Higher education	Agriculture	Opportunities	Success	Public-services
20	Information	City	Value creation	Lessons	Media

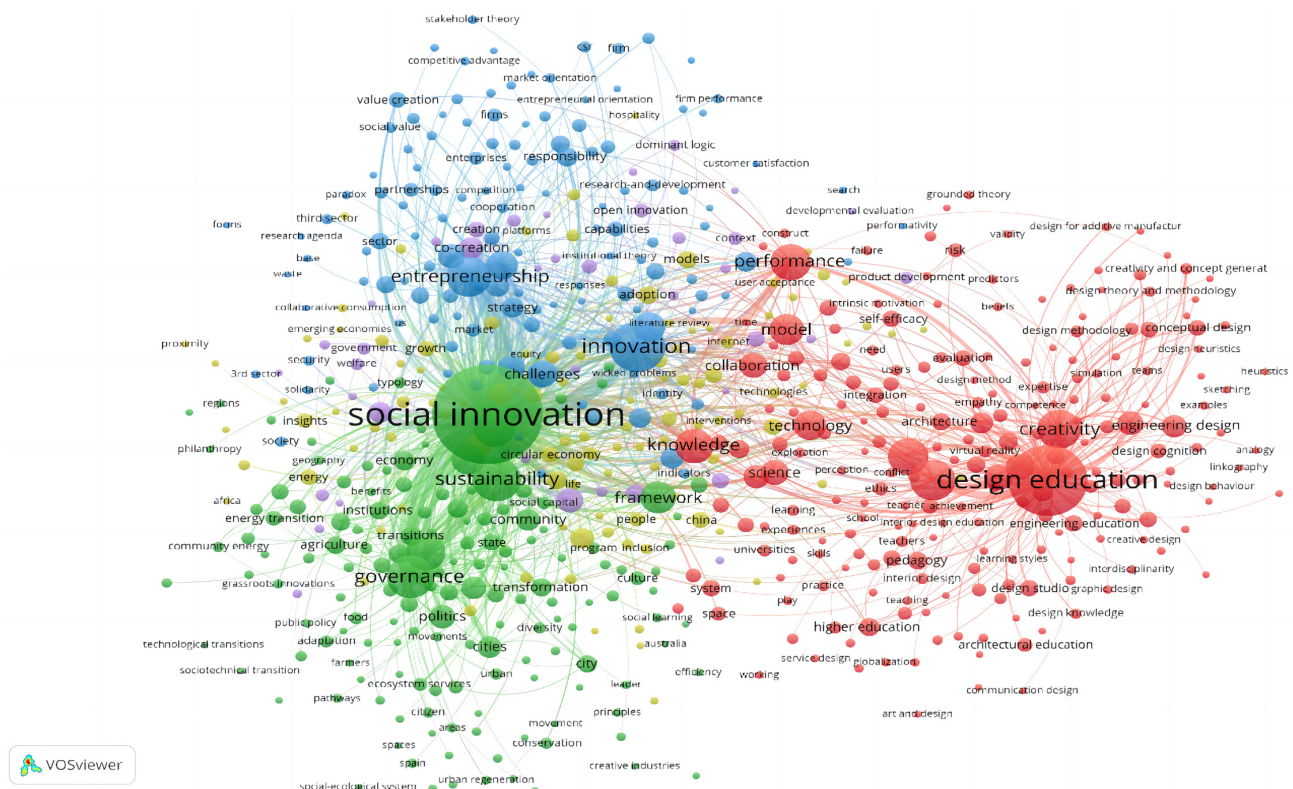


Figure 4. The network of subject terms.

3.2.2. Cross-Tabulation Analysis of the Domains

This analysis was centered around obtaining key information on the intersection of social innovation and design education and determining a pathway for the intersection of the two fields. This was accomplished by screening and analyzing the highly relevant subject terms for the two fields and determining the conceptual information about the subject terms using the labels of “connection strength” and “frequency of occurrence” (see Figure 5 below). The topics with total link strength values of over 500 included innovation, sustainability, performance, knowledge, creativity, framework, education, impact, and model. These topics had relatively large nodes and numbers of associations, indicating that they are highly recognizable and that much research has been carried out on these topics in the fields of social innovation and design education. Therefore, these topics can be investigated in the context of these fields. Moreover, to determine the nodes of the strongly associated thematic terms, only two major thematic terms in these fields were linked. This was important, as the integration of the two major themes needed to be explored. The themes for this analysis included motivation, self-efficacy, higher education, design thinking, communication, and case study. The analysis demonstrated that these keywords appeared more frequently in the research on social innovation and design education: They were used as methods, concepts, and judgment factors for the promotion of social innovation projects and the improvement of design education [7–24].

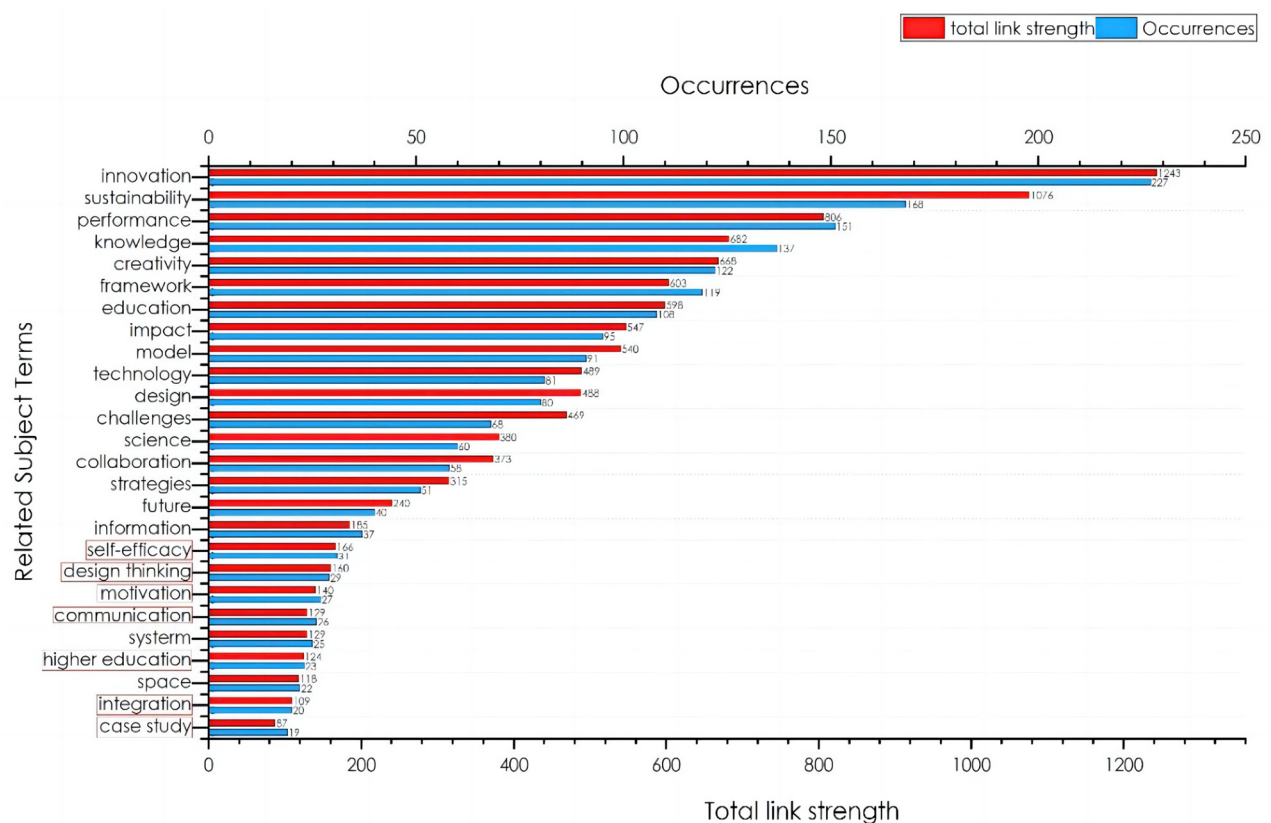


Figure 5. The association strength between the subject terms.

4. The Current Research and Knowledge Base

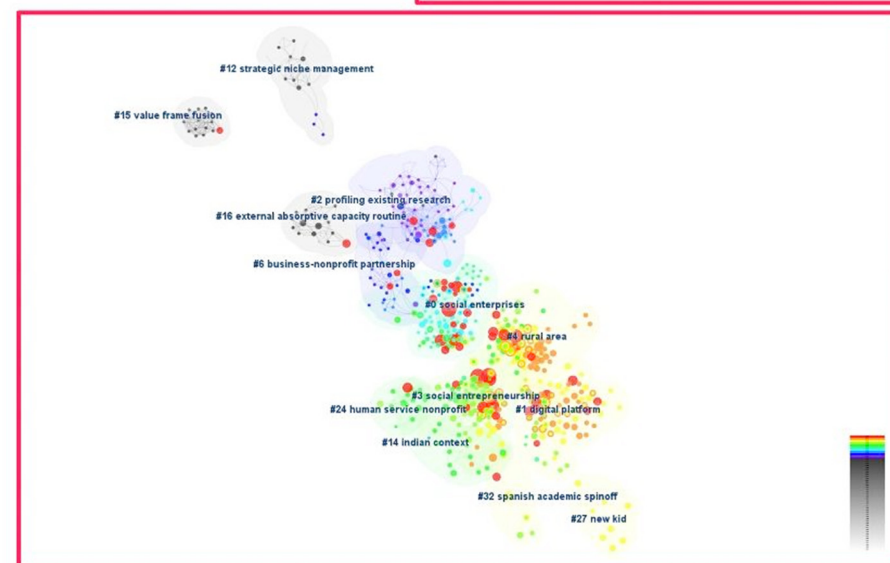
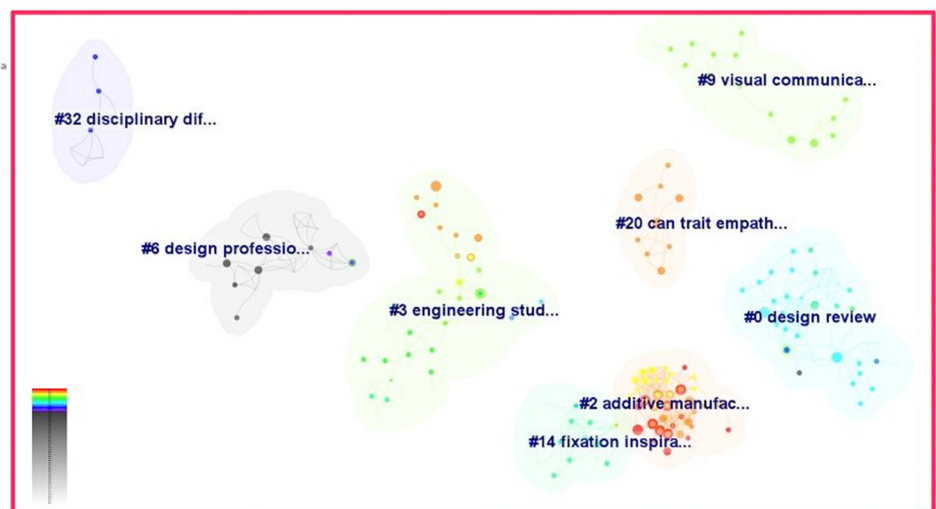
4.1. Co-Citation Analysis of the Literature

This analysis was conducted on 2588 documents on social innovation and design education published between 1970 and 2023. The data were extracted according to the domains to which they belonged, with Citespace's "Reference" and "Integrated Clustering" commands being used to obtain the co-citation analysis network for design education, which comprised 987 citations and 2205 links, and the co-citation analysis network for social innovation, consisting of 971 citations and 3416 links. The design education network was then divided into 262 clusters that had clear clustering ($Q = 0.9523$). Additionally, the social innovation network was divided into 115 clusters, which also had relatively clear clustering ($Q = 0.8257$). The studies' content was thus clearly delineated. The average silhouette value was 0.9738 for the design education category and 0.8775 for the social innovation category. These silhouette values were used to measure the networks' average homogeneity values, with high homogeneity being indicated by values closer to one. Therefore, the research content was more similar for the design education category than the social innovation category. Figure 6 details the clustering themes, with the higher silhouette values being included for both fields. Moreover, the smaller the clustering labels, the more important the content. The clustering of the design education category and the social innovation category are listed in the following order (Table 2). The design education category contained 186 citations (18%), and the social innovation category contained 512 citations (52%). The papers in the network are represented by nodes, and the lines and colors between the nodes reflect the co-citation relationship and the time intervals between them, with the warmer colors indicating the more recent relationships. Thus, the colors represent the evolution of these studies.

DESIGN EDUCATION

CiteSpace, v. 6.1.R6 (64-bit) Basic
 December 31, 2022 at 1:52:58 PM CST
 WoS: E:\file\design education citespace file\data
 Timespan: 1971-2022 (Slice Length=1)
 Selection Criteria: g-index (k=20), LRF=3.0, L/N=10, LB=5, e=1.0
 Network: N=987, E=2205 (Density=0.0045)
 Largest CC: 186 (18%)
 Nodes Labeled: 1.0%
 Pruning: None
 Modularity Q=0.9523
 Weighted Mean Silhouette S=0.9738
 Harmonic Mean(Q, S)=0.9629

#0 design review
 #2 additive manufacturing
 #3 engineering students ability
 #6 design professionals experience
 #9 visual communication design
 #14 fixation inspiration
 #20 can trait empathy
 #32 disciplinary differences framework



SOCIAL INNOVATION

CiteSpace, v. 6.1.R6 (64-bit) Basic
 December 31, 2022 at 8:47:02 PM CST
 WoS: E:\file\design education citespace file\data
 Timespan: 1970-2023 (Slice Length=1)
 Selection Criteria: g-index (k=20), LRF=3.0, L/N=10, LB=5, e=1.0
 Network: N=971, E=3416 (Density=0.0073)
 Largest CC: 512 (52%)
 Nodes Labeled: 1.0%
 Pruning: None
 Modularity Q=0.8267
 Weighted Mean Silhouette S=0.8775
 Harmonic Mean(Q, S)=0.8508

#0 social enterprises
 #1 digital platform
 #2 profiling existing research
 #3 social entrepreneurship
 #4 rural area
 #6 business-nonprofit partnership
 #12 strategic niche management
 #14 indian context
 #15 value frame fusion
 #16 external absorptive capacity routine
 #24 human service nonprofit
 #27 new kid
 #32 spanish academic spinoff

Figure 6. The clustering of the co-cited literature in the two fields.

Table 2. Domain clustering arrangement.

Rank	Design Education	Social Innovation
1	#0 design review	#0 social enterprises
2	#2 additive manufacturing	#1 digital platform
3	#3 engineering students ability	#2 profiling existing research
4	#6 design professionals experience	#3 social entrepreneurship
5	#9 visual communication	#4 rural area
6	#14 fixation inspiration, #20 can trait empathy	#6 business-nonprofit partnership
7	#20 can trait empathy	#12 strategic niche management
8	#32 disciplinary differences framework	#14 Indian context
9		#15 value frame fusion
10		#16 external absorptive capacity routine
11		#24 human service nonprofit
12		#27 new kid
13		#32 Spanish academic spinoff

The clusters that are arranged sequentially by silhouette values reflect the frequency of the studies in the labeled research areas, thus indicating the quality and prospective use of the clusters. The clusters were roughly divided into three periods: (1) the emergence period (gray); (2) the budding period (blue or purple); and (3) the takeoff period (green,

yellow, and orange). Thus, the clusters corresponding to the different periods were obtained (Table 3). Figure 6 delineates the topics of the studies in the two fields.

Table 3. Stages of domain clustering development.

Phase	Design Education	Social Innovation
The emergence period	#6 design professionals experience	#15 value frame fusion, #12 strategic niche management, #16 external absorptive capacity routine
The budding period	#32 disciplinary differences framework, #0 design review, #14 fixation inspiration, #3 engineering students ability, #9 visual communication design	#2 profiling existing research, #6 business-nonprofit partnership, #0 social enterprises #3 social entrepreneurship, #24 human service nonprofit, #14 Indian context
The takeoff period	#2 additive manufacturing, #20 can trait empathy	#4 rural area, #1 digital platform, #27 new kid, #32 Spanish academic spinoff

This clustering of the topics in the literature serves as an important source of field research development, with the literature being used to inform future studies by reflecting the important references and core discourses in the development of these studies. Higher co-citation frequencies reflect more substantial contributions to the fields' development. Therefore, this study carefully clustered the literature and also analyzed the highly co-cited literature by first examining the relationship between the cited studies and then analyzing the focus of attention to obtain a comprehensive understanding of the fields' development.

4.2. The Evolution of Design Education Research

The evolution of design education research is shown in Figure 7 below, with the entire emergence, budding, and takeoff periods being detailed in sequence. Throughout this evolution, enhancing students' design capabilities has always been the goal of design education, and the ways in which this goal can be achieved have become increasingly detailed and comprehensive due to the advancement of technology and overall knowledge. The blue arrows in Figure 7 indicate the use of technology in design education and the shift from specialized to comprehensive student competencies, while the orange dotted arrows point to the research that is oriented toward student empathy. These studies indicate the following: (1) Technology can be effectively integrated into design education and provide some assistance in the development of students' professional competencies; and (2) the development of students' integrative skills is a trend in design education, especially in terms of empathy, which will allow students to respond effectively to client relationships in the future [25–66].

4.3. The Evolution of Social Innovation Knowledge

The evolution of knowledge in social innovation is shown in Figure 8, in which the blue line indicates the studies that have evolved similarly and the orange dotted line indicates the studies that are relevant. Social innovation research is dominated by conceptual studies and case studies that integrate knowledge from multiple disciplines, enabling the concept to be continuously refined. As a result, the evolution of the research on this topic is based on changes to its definition as well as social problem solving. The early studies on social innovation provided a good knowledge base that allowed the subsequent large-scale studies to emerge. The strategic niche management content that has been covered in many subsequent studies, mostly as “nurturing niche” content, is highlighted in the purple box. In addition, the red box indicates the first studies on various types of social innovation, with many subsequent research directions being deepened and expanded from there. Moreover, the orange pointer indicates the relevant research content. From an evolutionary perspective, the research on social innovation has continued from earlier times to the recent past, indicating that there is still much room for theoretical research on this

topic and reflecting that problems have arisen in the practice of social innovation projects in reality. In addition, there is also strong research evolution in terms of the examination of for-profit and nonprofit organizations, which is reflected in the integration of values among organizations [8,20,67–145].

Evolution of research content in the field of design education

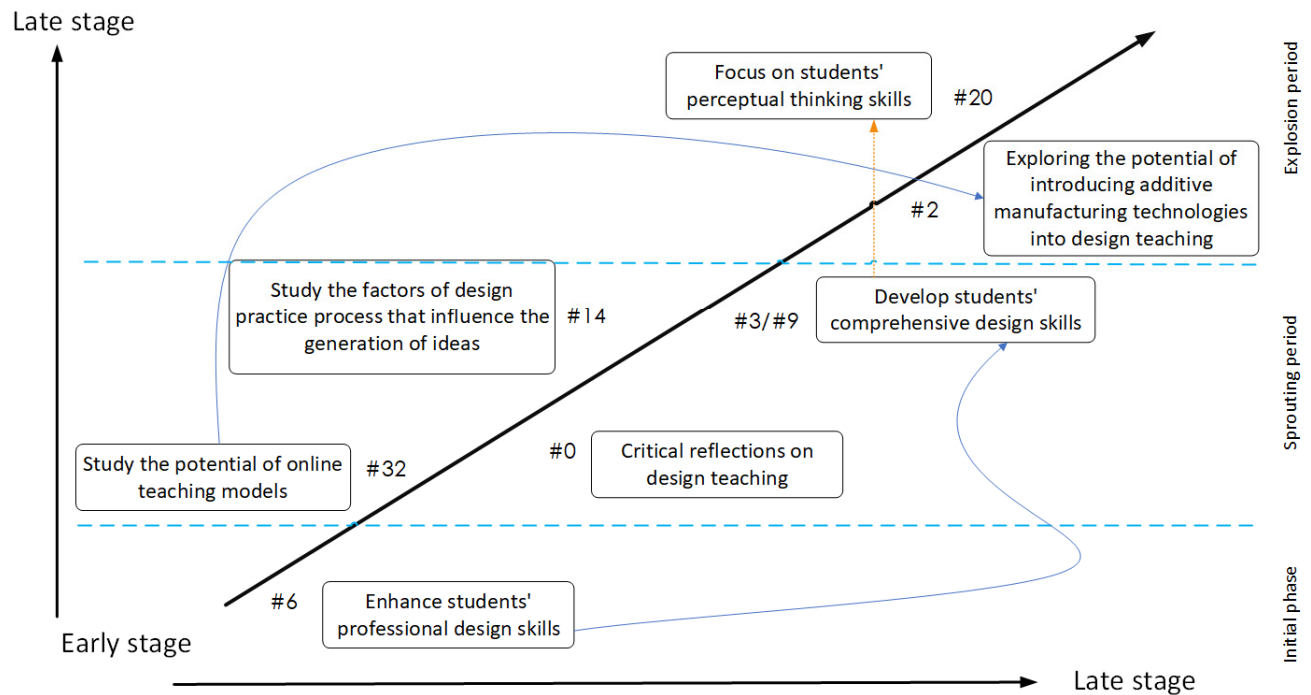


Figure 7. The evolution of design education knowledge.

Evolution of research content in the field of social innovation

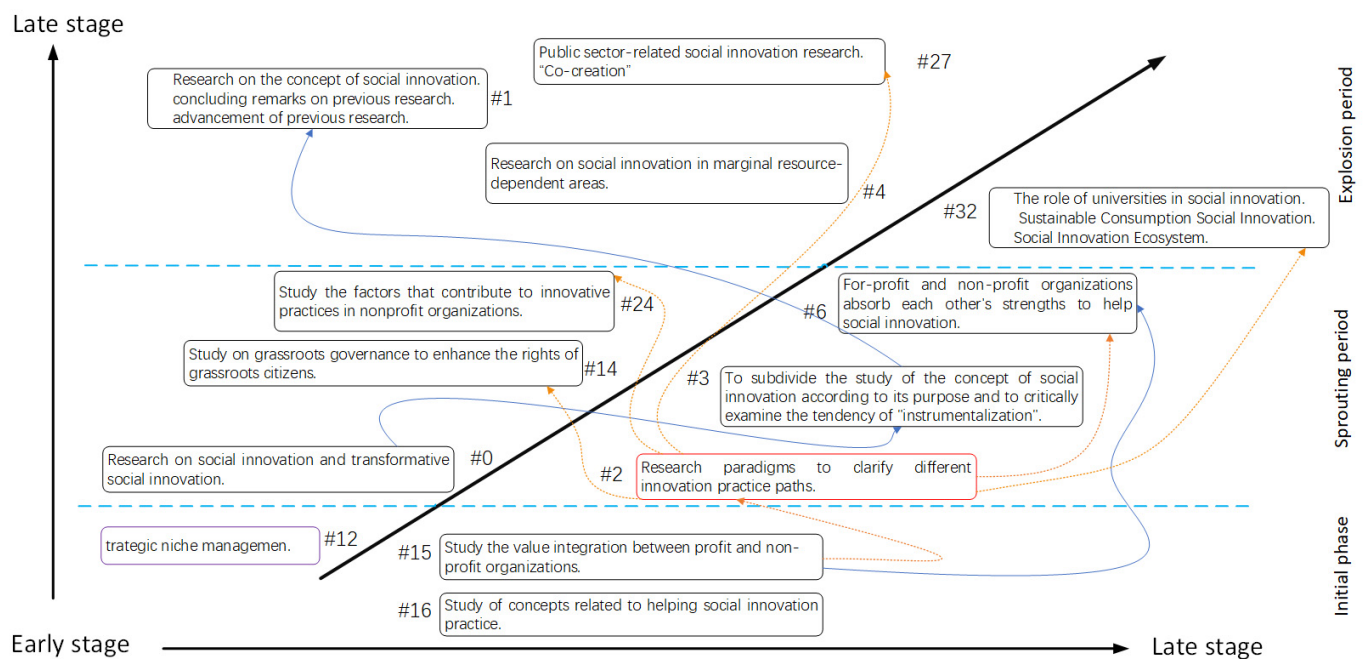


Figure 8. The evolution of social innovation knowledge.

5. Future Directions for Research

In order to determine the current and future research directions that have promise, the “Burst” function in Citespace was used for the visual and data-based analysis of the keywords that are used extensively in different periods in the literature (see Table 4). The keywords in the table represent the 11 keywords that were used extensively between 1970 and 2023. The “Year” column denotes the years in which the keywords began to be used extensively. The “Strength” column summarizes the frequency with which the keywords occur, which can be used to compare the keywords’ frequencies. The “Begin” and “End” columns represent the time intervals for the references. In this analysis, only the term “open innovation” was used extensively from 2021 to 2023, indicating that it is currently an important research topic and can still be researched in the future. The literature related to this subject term is then analyzed to obtain specific research directions.

Table 4. The frequency with which the top 11 keywords were used in the literature.

Keywords	Year	Strength	Begin	End	1992–2023
Design education	1992	50.98	1992	2014	
Engineering design	1999	8	1999	2014	
Design process	2004	4.32	2004	2012	
Engineering education	2005	4.77	2005	2012	
Engineering design education	2006	4.1	2006	2018	
Social entrepreneurship	2010	4.15	2010	2012	
Responsibility	2015	4.75	2015	2018	
Poverty	2017	4.28	2017	2019	
Social enterprise	2015	4.13	2018	2020	
Economy	2017	4.32	2020	2021	
Open innovation	2021	4.13	2021	2023	

A review of the literature on open innovation reveals that various branches of research on open innovation have been developed, including different organizations’ expansion of open innovation, the creation of a typology of open innovation that generates social benefits, and the study of open social innovation. With regard to this extension of open innovation by different organizations, a variety of social practices in combination with open thinking have been gradually developed in the public sector, within and outside companies, and in social enterprises. These innovations include: (1) public sector-led living laboratories created to promote the ability of stakeholders inside and outside the organization to create value collaboratively [146]; (2) responding to the shortage of ventilators due to the COVID-19 pandemic, ensuring open resource interoperability through the integration of corporate strengths, setting common goals, and collaborating to quickly achieve slow ventilator manufacturing cycles [147]; (3) using corporate social media to increase employees’ knowledge, promote knowledge sharing, and drive innovation productivity [148]; and (4) companies using social product development to promote market fit in product development in order to mobilize individuals to participate in new product ideas through social technologies and social mechanisms, thereby achieving creative collaboration and open thinking [149]. Regarding the creation of an open innovation typology, numerous open innovation cases are classified using the attributes related to the generation of social benefits, thereby distinguishing three types of open innovation that provide social benefits: (1) inclusive open innovation practices; (2) social open innovation practices; and (3) mass open innovation practices. This study uses the control and freedom of the knowledge provided by social enterprises to determine an understanding of open social innovation, and it proposes numerous considerations for open innovation practices [150]. This is informed by the case study, which found that the approach to sharing social innovation

information across organizational boundaries is complicated due to social impacts and financial sustainability [151]. This analysis of the literature highlights that open innovation emphasizes internal and external collaboration across organizations, resource interaction, and the promotion of social problem solving. Thus, it breaks through the traditional institutional and conceptual barriers of society and ensures the advantageous interoperability of social resources. This type of research will continue to develop in more directions in the future.

6. Discussion

This study investigated the development of design education and social innovation in order to obtain an entry point for the integration of the two research fields, for which the current state of research in the two fields was determined. The results of this study are divided into four parts: (1) descriptive statistical analysis; (2) co-occurrence analysis of keywords; (3) the status of the domains' research and knowledge evolution analysis; and (4) burst analysis. The results are presented below.

6.1. Descriptive Statistical Analysis

This analysis revealed that the literature in both fields grew rapidly between 2015 and 2020 and declined after peaking in 2021. This is similar to the year of publication for studies in the takeoff period in the knowledge evolution analysis, while the content of the studies demonstrates that there were many research directions in this period, which was a critical period of knowledge evolution. This conclusion aligns with the expected determination.

6.2. Co-Occurrence Analysis of the Keywords

This analysis showed that the five clusters' top 20 subject terms can be used to broadly summarize the development of the fields, thereby acting as a useful method for quickly understanding the current status of the fields. The five major research directions are: (1) design education; (2) agroforestry-related social innovation; (3) social innovation related to social organizations; (4) social innovation related to regional issues; and (5) social innovation related to cross-disciplinary collaboration. The initial entry points for the integration of the two fields were determined by investigating the subject terms used in both fields. Six highly correlated thematic terms were identified: (1) case study; (2) communication; (3) higher education; (4) design thinking; (5) motivation; and (6) self-efficacy. These words reflect the similar behaviors and thinking in the two domains, thus indicating that they can be effectively integrated. Figure 9 demonstrates that social innovation can be integrated into design education using these highly related thematic terms. These six subject terms can be divided into two directions: (1) the overall curriculum design direction represented by case studies, higher education, and design thinking, which focus on the social connections of the curricula and the strengths of the design discipline; and (2) the design of the content in the course, represented by communication, self-efficacy, and motivation, which focuses on participants' motivation and developing students' comprehensive abilities, thereby forming a different course design from traditional ones. Design education and social issues are often discussed as research points in both fields (see Figure 9), reflecting the key to the integration of these two research fields. Students and citizens are the main focus of both fields as they are the main source of motivation for improving education and social issues, as well as the key to ensuring that everyone benefits. The literature identified that using the keywords "case study" and "higher education" serves as a pathway to integrate these two fields, followed by "design thinking," in which "students" and "citizens" are combined. Thus, problems can be solved within the social innovation field. This is the path that will be used to integrate the ideas from this field (the cross-shaped arrow in Figure 9). The outer arrows of the cross in Figure 9 indicate the direction of the course content. The four transition points of the outer arrows represent design education, which is represented by "design education" and "student", and social innovation, which is represented by "citizen" and "social issues." Among them, "communication", "self-efficacy", and "motiva-

tion”, which are the theme words of design education, as the core elements for developing students’ design, understanding and mobilization skills. In addition, “self-efficacy” and “motivation”, which are the theme words of design education, are used as strategies to lead citizens to participate in social innovation. All of the above behaviors will eventually lead to social issues being solved through, for example, students being led by teachers or social innovation actors to solve social issues. Moreover, citizens will be encouraged by these actors to participate in social innovation and solve social issues. Solving social issues will also allow students to gain project experience and will afford citizens the opportunity to gain feedback on the benefits.

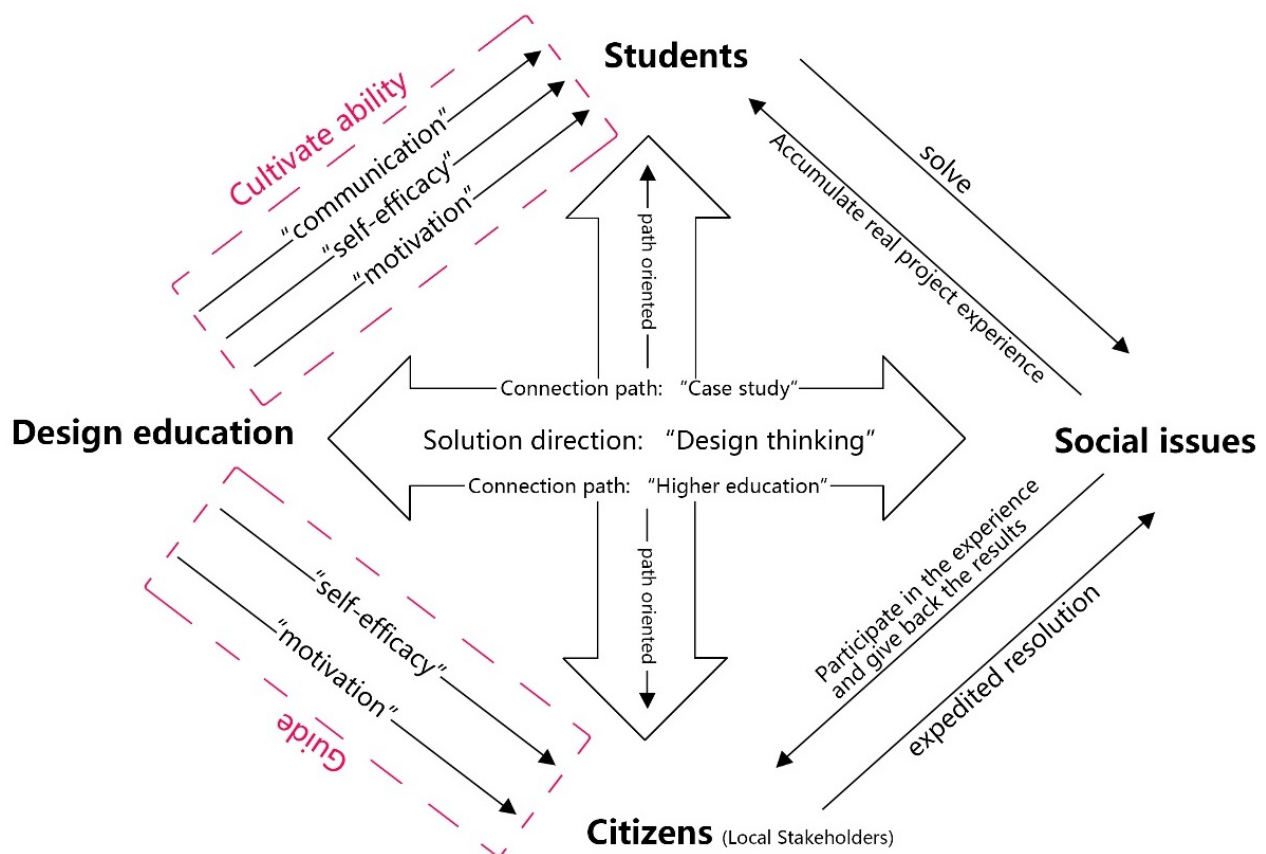


Figure 9. The integrated fusion path model.

6.3. The Status of the Domains’ Research, Knowledge Evolution Analysis, and Burst Analysis

The evolution of knowledge in design education has led to an increasingly comprehensive perspective on enhancing students’ design skills and the increasing importance of technology in design education, with empathy becoming the focus of current research. This focus is similar to caring for disadvantaged groups’ social problems in social innovation, which can act as an entry point for the integration of these two fields. In addition, the evolution of knowledge in social innovation integrates many disciplines and social relations, thus making the evolution of this knowledge complex. Practical and theoretical research has been conducted mutually, and the multidisciplinary interventions have improved social innovation theory while also demonstrating that the definition is still unclear. This has also led to the acceptance and critique of social innovation as a product that evolves with the times. Finally, at the end of the takeoff period for the evolution of social innovation knowledge, scholars began to pay attention to the role of universities, resulting in this becoming a research trend, which aligns with the ultimate purpose of this study. This period addresses universities’ social role from the perspective of their internal and external functions. The internal functions refer to universities having to: (1) incorporate stakeholders’ expectations

as part of their research; (2) cultivate stakeholders' ability to collaborate; (3) guide students to acquire the necessary skills to meet society's needs and to participate in interdisciplinary entrepreneurship education programs; and (4) elicit new knowledge-related research and skills. The external aspects refer to universities serving as: (1) consolidators of social capital and mediators of social organizational relationships; (2) hubs of credibility in countries to promote common knowledge resources; and (3) center points to promote skill transfer and the commercialization of training curricula. These elements can serve as entry points for the integration of social innovation in design education. In addition, the burst analysis showcased that open innovation has become a popular research topic and will continue to be one in the future. This indicates that open innovation can promote the opening of traditional institutional functions in the social system, with the ultimate goal of achieving innovation, which also aligns with the integration of social innovation into higher education and updates the traditional university education model.

7. Conclusions

This study investigated the cross-disciplinary nature and evolution of the research on design education and social innovation as a whole. Through a multi-faceted analysis, a clear research loop was achieved, from the pre-determination of basic literature to the demonstration of knowledge evolution. Thus, the development of the research on design education and social innovation was determined. Continuous research has been conducted in the field of design education to improve students' comprehensive design abilities, and it currently focuses on the enhancement of students' perceptual thinking and empathy, while the field of social innovation is defining the concept of social innovation through the mutual argumentation of practice and theory, thereby promoting the solutions to social and self-imposed problems. This study also clarified previous gray areas by first demonstrating the path of integration between the two domains through domain interaction analysis, and it concluded by determining the evolution of social innovation knowledge by explicating universities' role in social innovation. Furthermore, the burst analysis showed the role of open innovation in building institutional social relations, thus ensuring directions for future research, exploring the entry points for the integration of social innovation practices into design education from the perspective of universities' social relations. This study has some limitations, including only the WOS database being selected for the study and the keywords "social innovation" and "design education" being used to retrieve the data, which affected the scope of the study and impacted the use of the bibliometric software. Therefore, future studies can use more keywords or choose different databases to obtain a comprehensive understanding of the development of these fields. This study summarized the fields' important literature in an objective and rational manner to delineate important information about their development, thus providing a timely and objective source of information for scholars in both fields.

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