

Article

Interdisciplinary Knowledge Flow in International Higher Education Research: Characteristics and Mechanisms

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Abstract: Interdisciplinary knowledge flow provides methodological and theoretical support for solving complex problems in higher education. Based on Darcy's law, this study constructs a three-dimensional analysis framework for knowledge slope, knowledge stickiness, and flow medium, and combines it with bibliometric methods to analyze key words, references, and other information in 10 journals in JCR 1 or 2 higher education research (HER) fields from 2000 to 2022, so as to explore the characteristics and mechanisms of interdisciplinary knowledge flow in HER. The results show that, in the process of interdisciplinary knowledge flow in HER, the spillover amount of knowledge exchange between HER and other disciplines/fields is less than the absorption amount, and the direction of knowledge flow is knowledge-importing. The phenomenon of reciprocal assimilation between HER and other disciplines/fields is significant, and the knowledge network shows the characteristics of family resemblance. Interdisciplinary knowledge flow in HER is influenced by three factors, among which knowledge slope plays a promoting role, knowledge stickiness plays a hindering role, and the flow medium has a gatekeeper effect in the process.

Keywords: higher education research; interdisciplinary knowledge flow; Darcy's law; bibliometrics



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1. Introduction

As an open field of study, researchers of higher education often adopt knowledge from various disciplines/fields to solve complex problems in the field, which leads to the complexity and plurality of its knowledge sources and knowledge composition (Wang, 2010). Bess and Clark (1985) not only showed that higher education is a multidisciplinary open research field but also revealed the source and composition of knowledge in higher education to a certain extent. As an important knowledge carrier, higher education research (HER) is the result of the continuous cultivation of researchers in the field, and it is also the greenhouse of the interaction between knowledge from various disciplines. After some screening, knowledge from various fields flows into HER and is applied by higher education researchers (HERers), forming the interdisciplinary phenomenon of HER and promoting the interdisciplinary knowledge flow of HER. In this process, the knowledge production and evolution of HER continue to increase. While promoting the constant reorganization and transformation of knowledge in this field (Piaget, 2002), the integration of HER and various fields or methods forms a new and richer knowledge category (Mitchell, 1995), which promotes the continuous progress and development of HER. Simultaneously, the important value of interdisciplinary knowledge flow among different research fields

has attracted the attention of many scholars, especially in the presentation and measurement of interdisciplinary knowledge flow (Yang & Liu, 2022).

In previous studies, researchers have proposed a variety of methods to quantify interdisciplinary knowledge flows (Liu et al., 2017a). The most common interdisciplinary research is based on citation behavior (L. Zhang et al., 2016; Zhu & Yan, 2015). Many scholars believe that the occurrence of citations leads to knowledge exchange or integration between disciplines and is a process involving the creation of new knowledge (Wagner et al., 2011). Some scholars have also measured the degree of interdisciplinarity presented by interdisciplinary knowledge flows on related research topics using indicators or media such as formulas (Pratt, 2010), teamwork outputs (Porter et al., 2008), and research outcomes (Y. Wang et al., 2017). For example, Zhou et al. (2023) directly proposed a multidimensional framework to quantify interdisciplinary knowledge flows, revealing the degree of interdisciplinarity in different disciplines from a three-dimensional framework of breadth, intensity, and homogeneity. However, there is some debate as to whether co-authorship by researchers from different disciplines can lead to knowledge integration in interdisciplinary research. While some scholars are in favor of this (Porter et al., 2007), others argue that knowledge integration is an epistemological category, and that the measurement of interdisciplinarity should depend more on the content of the research outputs than on cooperation and affiliation (Rafols & Meyer, 2007). Taken together, many papers have explored some aspects of interdisciplinarity and knowledge flows, such as analyzing interdisciplinarity in terms of a theme (Rafols & Meyer, 2009) or measuring interdisciplinarity in some fields or disciplines through citation behavior (Liu et al., 2017b; Albert et al., 2022a). However, there is a lack of exploration of the characteristics of interdisciplinary knowledge flows in HER.

To elucidate this process, this study analyzes the data of 10 journals in the field of HER published in JCR 1 or 2 between 2000 and 2022, and presents the interdisciplinary path of knowledge absorption and knowledge diffusion in HER by means of bibliometrics. On the one hand, the pattern analysis and characteristics summary of the knowledge composition structure of various disciplines in HER are carried out. On the other hand, this study also explores the influencing factors and rules of interdisciplinary knowledge flow in HER. This will not only help the academic community of HER to have a deeper understanding of the characteristics and rules of interdisciplinary knowledge flow in HER and broaden the depth and breadth of HER, but will also help HERers to combine the rules of interdisciplinary knowledge flow in HER and better adopt a multidisciplinary approach to solving the complex problems faced in reality.

2. Theoretical Framework

Knowledge, as an intangible fluid, also shares some general properties with tangible fluids, particularly in terms of the structure, characteristics, and influencing factors of its flow. Regarding structure, knowledge is a fluid-like substance, which consists of structured experiences, values, information with specific meanings, and expert insights (Davenport & Prusak, 2000). This process involves at least three essential elements: the knowledge source, transmission path, and knowledge recipients (Davenport & Prusak, 2000). Other scholars suggest that knowledge flow refers to the process or mechanism through which knowledge circulates between individuals, influenced by three key factors: the subject, content, and direction (Zhuge, 2002). In terms of the characteristics of knowledge flow, research indicates that significant effects, such as flow field effects (Abramo & D'Angelo, 2020) and potential difference effects (Zhuge et al., 2007), occur during the process. Influencing factors include both internal and external elements, such as the medium of knowledge (Park & Kang, 2009), the stickiness of knowledge (F. Zhang et al., 2020), and

external environmental conditions (Cummings & Teng, 2003). This resembles the flow characteristics of fluids in porous media, as described by Darcy's law. This law was established by the French physicist Henry Darcy, who conducted in-depth research on fluid permeation in porous geological media and identified the relationship between fluid flow and various influencing factors (Whitaker, 1986). The basic equation of linear seepage law is as follows:

$$Q = AkJ = A \frac{\gamma}{\mu} \frac{\Delta h}{L}$$

In this equation, Q represents the flow rate, A is the cross-sectional area of the medium, k is the permeability coefficient, and J is the hydraulic gradient. Specifically, the fluid permeability (Q) is directly proportional to the cross-sectional area (A), the medium's permeability (γ), and the flow loss (h), while it is inversely proportional to the fluid properties (μ) and the seepage length (L).

According to Darcy's law, the influences on the flow of knowledge from the knowledge source to the knowledge recipient are also related to several of the above factors. First, although the seepage section area can be regarded as the communication link of knowledge flow by analogy to the process of knowledge flow, HER, as an open research field, objectively has the same level of links for various subject fields without any significant difference. Secondly, regarding fluid properties, knowledge fluids also have their own properties, i.e., knowledge stickiness. The concept of knowledge stickiness derives from Von Hippel's (1994) research on information stickiness. Szulanski (1996) believed that knowledge experiences difficulty flowing between disciplines because of its specificity, complexity, and internal recessiveness. Medium permeability is the mechanism of knowledge transmission and plays a screening role in the flow of knowledge to the first degree. Third, medium permeability is the medium through which knowledge is disseminated, invisibly controlling what kind of knowledge can flow into HER and filtering the flow of knowledge. Finally, compared to the concept of potential difference in fluid mechanics, the driving force of knowledge flow is the knowledge potential difference.

Theoretically, the greater the knowledge potential difference between knowledge subjects, the better the knowledge flow effect will be. However, the influence of flow distance still exists among knowledge subjects, resulting in differences in knowledge flow across various disciplines in HER. This is expressed in fluid mechanics as the hydraulic gradient, which is the ratio of the vertical height of the flow to the length of the seepage flow. There is a similar relationship between knowledge potential difference and flow distance in knowledge flow; in this study, the ratio of knowledge potential difference to flow distance is defined as knowledge slope, which represents the dynamic and distance relationship between knowledge "subject" and knowledge "acceptor".

Therefore, based on Darcy's law, and combined with the characteristics of knowledge flow in HER, an analytical model for how the comprehensive construction of knowledge flow effects in HER is obtained, in which knowledge flow in HER is influenced by three factors. The first factor is the knowledge slope, the ability of knowledge absorption and diffusion under the influence of the knowledge potential difference between the knowledge source and the knowledge acceptor and flow distance. The second is knowledge stickiness, denoting the characteristics of knowledge itself, such as specificity, complexity, and recessiveness. The third is medium permeability, the medium communicating between the knowledge source and knowledge acceptor. The specific relationships are shown in Figure 1.

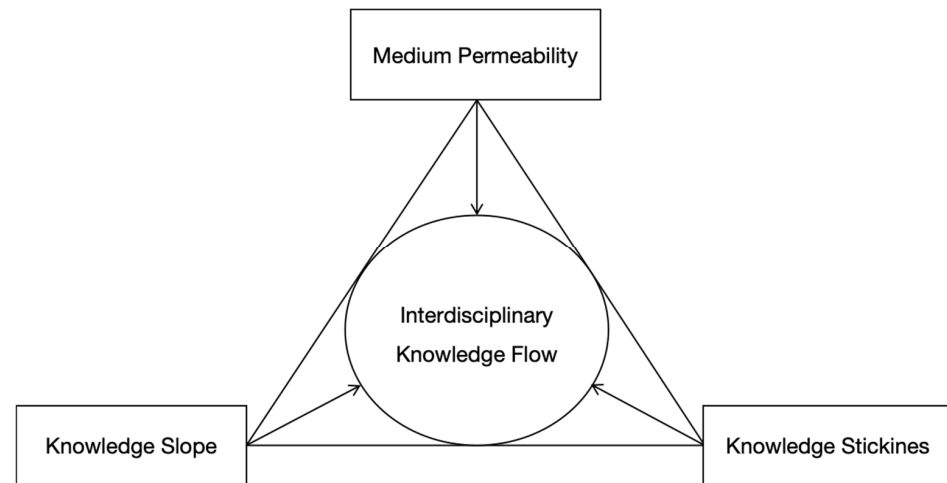


Figure 1. Interdisciplinary knowledge flow structure.

3. Methodology

3.1. Data Selection and Processing

This study selected 10 highly cited journals in the higher education Journal Citation Reports 1 and 2. These include Studies in Higher Education, Higher Education, HER and Development, Teaching in Higher Education, Review of Higher Education, Assessment & Evaluation in Higher Education, Journal of Higher Education, Research in Higher Education, International Journal of Sustainability in Higher Education, and Internet and Higher Education. Through the Web of Science database, all the literature in the above-mentioned journals was searched from 1 January 2000 to 31 December 2022, and a total of 13,644 search results were obtained. The literature retrieval type was locked as an article, and 11,224 pieces of data were retrieved. Using these as the original data and removing missing and incomplete information, 10,542 pieces and 302,111 references of data were obtained. The relevant information was then sorted out from the final literature, and keywords, authors, references, and other information were extracted for follow-up research.

3.2. Research Tools and Measurement Methods

The data were statistically analyzed using a bibliometric method, and the results were visualized using VOSviewer, Pajek, and other software packages. First, this study constructs a domain overlay map based on the global maps of science, visualizes the citing references and cited references in the data, and demonstrates the relationship between knowledge slope and interdisciplinary knowledge flow in HER. Secondly, based on the average time of keywords appearing in HER from 2000 to 2022 and the characteristics of low-frequency keywords in HER knowledge flow, this study explores the relationship between knowledge stickiness and interdisciplinary knowledge flow in HER. Finally, based on the domain distribution of high-frequency keywords in the knowledge flow of HER, the study explores the relationship between the flow medium and the interdisciplinary knowledge flow of HER.

4. Results

4.1. Knowledge Slope and Interdisciplinary Knowledge Flow in HER

To better show the knowledge potential difference and flow distance between various subject areas and HER, this study produced a domain overlay map of knowledge absorption and diffusion in HER based on the data of knowledge absorption and knowledge diffusion in HER combined with global maps of science (Leydesdorff et al., 2012). The results are shown in Figures 2 and 3.

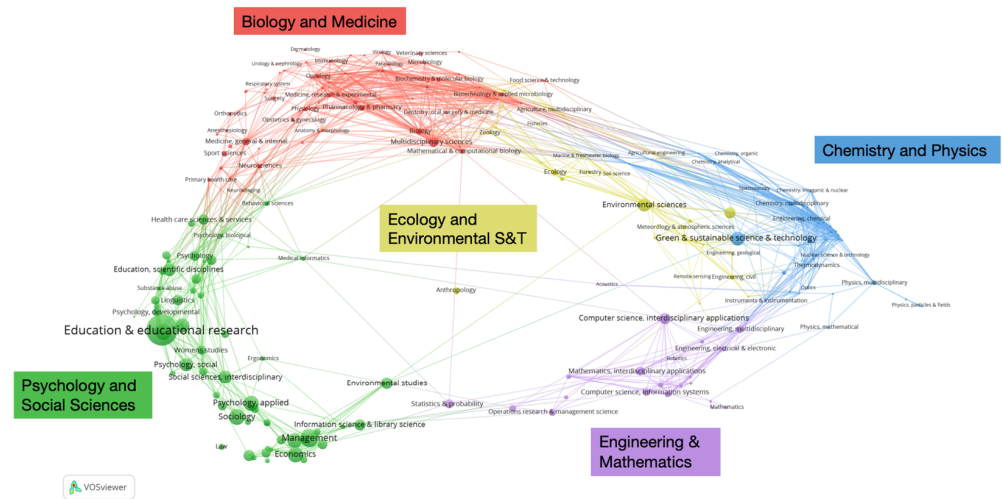


Figure 2. Domain overlay map of knowledge absorption in HER.

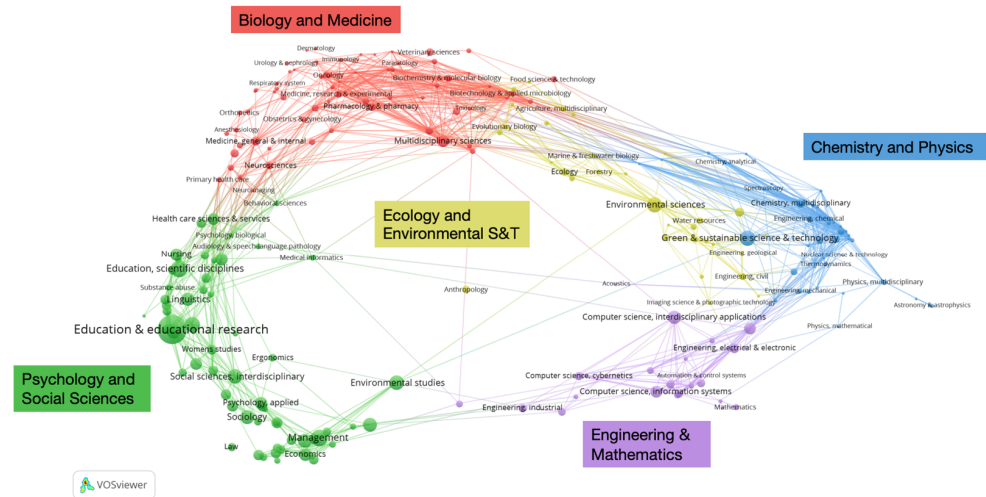


Figure 3. Domain overlay map of knowledge diffusion in HER.

As shown in Figures 2 and 3, HER primarily focuses on knowledge absorption and diffusion activities in Psychology and Social Sciences, mainly in relation to Education and Educational Research, Management, Sociology, Psychology, and Economics. The flow of knowledge generated in the remaining four categories was relatively small and was only relatively large in individual disciplines/areas. Examples include Environmental Sciences in Chemistry and Physics, Green Sustainable Science in Ecology and Environmental S&T Technology, Engineering and Mathematics in Computer Science, interdisciplinary applications, Biology, and Multidisciplinary Science in Medicine. The results show that, under the premise of knowledge potential differences between HER and various disciplines/fields, the flow distance between the subjects of knowledge flow is also affected.

The greater the knowledge potential difference, the more knowledge can flow; the larger the tissue distance, that is, the longer the flow distance between the two, the slower the flow. Knowledge potential differences promote knowledge flow in HER, whereas flow distance has the opposite effect. For example, in the same subject fields of Psychology and Social Sciences, the knowledge absorbed by HER in psychology is higher than that in law precisely because knowledge in the field of psychology is more fluid for HER. In different subject areas, HER notably absorbs less knowledge in the fields of Chemistry and Physics, Ecology and Environmental S&T, Engineering and Mathematics, and Biology and Medicine. This is not only because the knowledge in these four areas has a relatively high

level of difficulty in flowing into HER, but also because the organizations are far away, resulting in the difficulty of knowledge flow. Second, from the perspective of knowledge diffusion, the knowledge flow activities of disciplines/fields in Psychology and Social Sciences in HER are significantly higher than those in other scientific categories, indicating that the process is affected by flow distance. Based on these results and Darcy's law, the relationship between knowledge potential difference and flow distance can be expressed by the knowledge slope, which is the ratio of the two. The greater the ratio, the greater the knowledge slope, and the easier the knowledge flow. As shown in Figure 4, the knowledge potential difference between each subject area and HER can be regarded as the height of the right triangle, the flow distance between each subject area and HER as the base of the right triangle, and the knowledge slope as the slope of the right triangle.

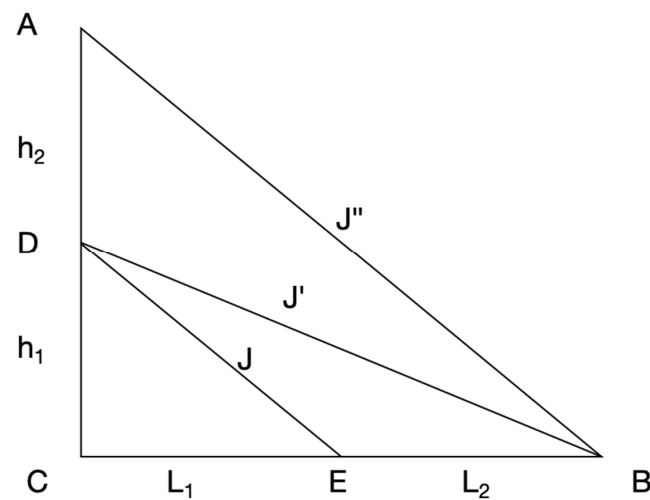


Figure 4. Knowledge Potential Difference, Knowledge Distance, and Knowledge Slope.

The figure shows that, under the same knowledge potential difference, the greater the flow distance, the smaller the knowledge slope, and the knowledge slope between the knowledge flow subjects (DE) is greater than that of DB ($J > J'$). Under the same flow distance, the greater the knowledge potential difference, the greater the knowledge slope; for example, the knowledge slope between knowledge flow subjects AB is greater than that of DB ($J'' > J'$). In the knowledge flow of HER, disciplines or fields at the same distance from HER have different impacts due to the varying knowledge potential differences between each discipline and HER's knowledge structure. Additionally, the impacts of disciplines or fields at different distances are influenced by both the flow distance and the differences in knowledge potential, creating the knowledge flow phenomena illustrated in Figures 2 and 3. For example, although there is a large knowledge gap between various disciplines in HER, such knowledge gaps will not flow into HER at a high speed and efficiency because of the distance from the organization of HER. Furthermore, the knowledge flow of HER is aimed at knowledge that can be incorporated into the knowledge structure of HER; knowledge that is not directly related to HER needs to be associated with more research and serve as a structural hole to build a bridge of knowledge flow between HER and other disciplines/fields. Therefore, knowledge flow in HER is related to the knowledge slope.

4.2. Knowledge Stickiness and Interdisciplinary Knowledge Flow in HER

In the fluid flow process, the stickiness of the physical fluid causes its fluid molecules to adhere to the flow pipe, making flow difficult, and part of the mechanical energy of the fluid is converted into heat, resulting in energy loss. Similarly, the stickiness of knowledge fluid is called knowledge stickiness. In the knowledge flow field of HER, the speed

and efficiency of knowledge flow will also lead to loss of knowledge because of the existence of “friction resistance”. However, several factors also affect knowledge stickiness. Through an empirical analysis of data, Szulanski (1996) concluded that the lack of knowledge absorption capacity of the receiver, the ambiguity of cause and effect, and the difficult relationship between the source of knowledge and the receiver dominated the obstacles to knowledge transfer related to motivation. He believed that there are four categories of factors within an organization that affect the stickiness of knowledge: characteristics of the transferred knowledge; characteristics of the knowledge source; characteristics of the knowledge recipient; and the transfer environment (Szulanski, 1996). Simonin (1999) used empirical research to identify the causes of knowledge ambiguity in the process of knowledge transfer, which is derived from knowledge implicativeness, complexity, specificity, experience, partner protection, and cultural and flow distance. Some scholars even put forward relevant solutions to the stickiness of knowledge in the course teaching process (Daugule & Kapenieks, 2019).

In this study, the flow of knowledge in HER is also affected by knowledge stickiness, which is mainly affected by the characteristics of knowledge itself, including its complexity, internal recessiveness, and specificity. The higher the complexity of knowledge, the higher the internal recessiveness and specificity of knowledge, the higher the knowledge stickiness, and the slower and more difficult the flow of knowledge. As shown in the keyword graph of HER in Figure 5, most keywords with a short average occurrence time are proper nouns, such as sustainability, mobility, and burnout. The average time of occurrence in HER was 2018, indicating that the flow of HER was slow. Furthermore, the time is late. As can also be seen from Table 1, HER has difficulty generating knowledge flows in Mycology, whether through knowledge absorption or diffusion. In contrast, education, students, and universities in Education and Educational Research have always been at the center of HER. This is not only related to the potential difference and flow distance of mobile knowledge between various disciplines/fields and HER but is also significantly related to knowledge stickiness in various disciplines/fields. Some disciplines’ proper names and proprietary academic terms are difficult to flow into other disciplines, not only due to the rigor of their disciplinary knowledge systems but also because of the self-maintenance of their academic discourse. This creates disciplinary barriers that are difficult to overcome. The higher the complexity, implicitness, and proprietary degree of the knowledge itself, the more challenging it is for it to flow into other fields of research, resulting in a slower knowledge flow.

Table 1. Ranking of the Bottom 10 Keywords of Knowledge Flow in HER.

Knowledge Absorption	Knowledge Diffusion
Acoustics	Materials Science Paper Wood
Anatomy Morphology	Medieval Renaissance Studies
Materials Science, Characterization and Testing	Polymer Science
Materials Science, Coatings and Films	Allergy
Meteorology Atmospheric Sciences	Engineering Petroleum
Mineralogy	Mycology
Ornithology	Physics Nuclear
Quantum Science and Technology	Quantum Science Technology

Table 2. Cont.

WOS Category	N	302,111
Green and Sustainable Science and Technology	7330	2.43%
Psychology, Social	5987	1.98%
Environmental Sciences	5633	1.86%
Social Sciences, Interdisciplinary	5528	1.83%
Education, Scientific Disciplines	5005	1.66%
Environmental Studies	3880	1.28%
Information Science and Library Science	3332	1.10%
Political Science	3271	1.08%
Computer Science, Interdisciplinary Applications	3168	1.05%
Engineering, Environmental	3112	1.03%
Health Care Sciences and Services	2827	0.94%
Linguistics	2740	0.91%
Social Sciences, Mathematical Methods	2299	0.76%
Multidisciplinary Sciences	2058	0.68%
Public, Environmental and Occupational Health	2016	0.67%
Psychology	2010	0.67%
Psychology, Experimental	1955	0.65%
Communication	1872	0.62%
Geography	1790	0.59%
Statistics and Probability	1726	0.57%
Industrial Relations and Labor	1708	0.57%
Public Administration	1654	0.55%

The literature was also processed by citing original data and a total of 118,424 articles were identified. The communication ratio of HER was less than 1 ($118,424/302,111 < 1$); therefore, HER is currently in the stage of knowledge input. After downloading and processing the WOS categories of 118,424 articles, there were 251 source disciplines of knowledge diffusion in HER, which is slightly lower than the knowledge absorption. The diffusion intensity of each discipline is listed in Table 3 (top 30). Education and Educational Research still occupies a dominant position, accounting for 22.42%, whereas other disciplines account for a relatively small proportion, with only 12 disciplines representing more than 1%. Education Scientific Disciplines rank second at 2.36%, followed by Management at 2.04%, Green Sustainable Science Technology (1.55%), and Environmental Sciences (1.45%). This shows that, in addition to the self-drawing of HER, knowledge is also returned to the subject and absorbed to form a knowledge interaction and exchange. Additionally, these results show that compared with the subject/field of knowledge absorption in HER, the order of the two disciplines in the diffusion of knowledge changes, although there is no great innovation in the category. Valuable knowledge for various fields can be extracted from the topics/questions of HER; for example, some scholars analyze students' academic engagement through the classroom performance of college students (Mishall et al., 2022; Taşkın & Kılıç Çakmak, 2022). Others explore smart campus issues through the sustainable development of students' key abilities (Zaballos et al., 2020). In summary, the more

similar the research themes/issues are to those of concern to HER, the more frequent the flow of knowledge between HER and this discipline/field.

Table 3. Knowledge Diffusion in HER (Top 30).

WOS Category	N	124,536
Education and Educational Research	67,495	22.42%
Education Scientific Disciplines	7108	2.36%
Management	6142	2.04%
Green Sustainable Science Technology	4661	1.55%
Environmental Sciences	4361	1.45%
Psychology Multidisciplinary	4204	1.40%
Social Sciences Interdisciplinary	3861	1.28%
Environmental Studies	3766	1.25%
Psychology Educational	3465	1.15%
Sociology	3311	1.10%
Business	3228	1.07%
Information Science Library Science	3175	1.05%
Linguistics	2868	0.95%
Computer Science Interdisciplinary Applications	2521	0.84%
Economics	2294	0.76%
Psychology Applied	2280	0.76%
Public Environmental Occupational Health	2090	0.69%
Language Linguistics	2047	0.68%
Nursing	1893	0.63%
Psychology Social	1583	0.53%
Engineering Multidisciplinary	1540	0.51%
Health Care Sciences Services	1536	0.51%
Multidisciplinary Sciences	1512	0.50%
Computer Science Information Systems	1449	0.48%
Communication	1228	0.41%
Hospitality Leisure Sport Tourism	1202	0.40%
Geography	1153	0.38%
Political Science	1123	0.38%
Public Administration	1036	0.34%
Social Work	935	0.31%

5. Discussion

In this paper, we used Darcy's law to establish an interdisciplinary knowledge flow analysis framework for HER. Bibliometric methods were also applied to present the patterns of interdisciplinary knowledge flow in HER. This reflects the complex phenomena of cross-disciplinary knowledge absorption and diffusion between HER and other disciplines/fields, forming a unique knowledge flow field within HER. This process is influenced by the knowledge slope, knowledge stickiness, and the knowledge flow medium.

Based on the characteristics and mechanisms of interdisciplinary knowledge flow in HER, educational administrative bodies, research institutions, and universities can develop more effective teams and organizational structures in today's rapidly changing social environment. This will foster cross-disciplinary and cross-field cooperation, transforming knowledge into practical actions to solve environmental and social problems. It will also help address complex real-world issues through multidisciplinary approaches. Furthermore, for HERers, understanding the patterns of interdisciplinary knowledge flow can provide valuable insights and innovative inspiration, helping them discover new knowledge combinations and points of innovation to optimize the content and structure of HER.

5.1. Characterization of Interdisciplinary Knowledge Flows in HER

5.1.1. The Direction of Interdisciplinary Knowledge Flows in HER Is Knowledge-Importing

The exchange ratio theory defines the type of flow of disciplines in the process of knowledge diffusion and exchange, which refers to the ratio of the number of documents citing a discipline to the number of documents being cited by the same discipline in the interdisciplinary citation network. A ratio of less than 1 indicates that the knowledge overflow of a discipline is less than its absorption, indicating an input-type discipline. On the other hand, a ratio greater than 1 indicates an output-type discipline (Yue & Xu, 2019). In the interdisciplinary knowledge flow of international HER during 2000–2022, the number of references cited by HER institutes is greater than the number of references cited in their literature; their knowledge spillovers are smaller than their knowledge uptake; their knowledge exchange ratio is less than 1 ($118,424/30,211 < 1$); and their knowledge flow is knowledge-importing (Rodríguez, 2017). Disciplinary potential energy theory suggests that the relative position between two different disciplines in a scientific system through citation relationships creates a disciplinary potential energy, which divides the disciplines into upstream and downstream relationships and reveals the direction of knowledge flow between disciplines (Lv & Li, 2021). In the field of Social Sciences and Humanities, Psychology, Sociology, History, and Philosophy are upstream and less volatile, exporting knowledge to other disciplines (Lv & Li, 2021). Higher education studies is at the downstream end of the Psychology and Social Sciences spectrum, and is subject to the knowledge outputs of the upstream disciplines of Education and Educational Research, Management, Sociology, Psychology, and Economics. Studies have shown that Philosophy, History, and Language often act as exporters of knowledge to other disciplines, while Education and Sociology often act as importers that absorb knowledge from other disciplines (Urata, 1990). This correlates more with disciplinary closure or openness to external knowledge (Truc et al., 2023).

5.1.2. Interdisciplinary Knowledge Flows in HER Present Knowledge Networks of Family Resemblance

Piaget considered interdisciplinarity to be the result of “reciprocal assimilation” between disciplines, in which both or all the disciplines involved are transformed through interaction (Klein, 1990). In the process of interdisciplinary knowledge flow in HER, the phenomenon of “reciprocal assimilation” between disciplines/fields is also very significant, and Wittgenstein (1953) referred to this characteristic as “family resemblance”. The research themes/problems involved in HER are common issues across numerous disciplines. Researchers use knowledge from various disciplines/fields to explain, reveal, and solve research themes/problems in higher education. Various types of knowledge create certain connections among each other in the field of higher education, forming research communities around specific topics, thus forming a unique knowledge network structure for HER (Sorenson et al., 2002). During the knowledge flow process of HER from 2000 to 2022, the

disciplines/fields with a larger flow of knowledge are mostly those close to the field of HER. Although the knowledge flow of distant disciplines seems numerous in terms of types, the proportion distributed among individuals is small. Looking at the five major areas of the science map, HER mainly engages in knowledge absorption and diffusion activities within Psychology and Social Sciences, with relatively less knowledge flow occurring in the other four areas, but with some potential for development. From a micro-disciplinary perspective, HER mainly involves the flow of knowledge in disciplines such as Education and Educational Research, Management, Sociology, Psychology, and Economics, with smaller proportions in other disciplines, and the overall characteristic of interdisciplinary knowledge flow is significant. Among them, the knowledge flow between HER and Education and Educational Research accounts for the most, with a knowledge absorption proportion of 37.77% and a knowledge diffusion proportion of 22.42%.

5.2. Mechanism of Interdisciplinary Knowledge Flow in HER

5.2.1. Knowledge Slopes Facilitate Interdisciplinary Knowledge Flows in HER

The ratio of the knowledge potential difference to the knowledge slope represents, to a certain extent, the capacity for interdisciplinary knowledge flow in HER. The knowledge potential difference promotes the flow of knowledge in HER, while the distance of flow has the opposite effect. Thus, interdisciplinary knowledge flow in HER is influenced by both the knowledge potential difference and the distance of flow. Therefore, although knowledge from distant disciplines that differ significantly from HER has a certain potential for flow, the distance between them is too great, and the knowledge that can participate in the flow must be filtered through the knowledge gatekeepers of various disciplines/fields to enter into HER. This makes it difficult to form large-scale and organized flows, characterized by randomness and looseness, such as in the fields of Chemistry and Physics, Ecology and Environmental S&T, Engineering and Mathematics, and Biology and Medicine. Relevant studies also indicate that, from the perspective of knowledge distance, if there is shared knowledge between the knowledge source and the knowledge receptor, it will make the transfer easier (Dixon, 2000). Disciplines in the Psychology and Social Sciences fields, which are closer to HER in terms of distance, are more likely to engage in knowledge flow with it, such as Management, Sociology, Psychology, and Economics. This is also one of the reasons for the formation of the “family resemblance” knowledge network.

5.2.2. Knowledge Stickiness Hinders Interdisciplinary Knowledge Flow in HER

The higher the complexity, tacitness, and proprietary nature of knowledge itself, the more difficult it is to flow into research in other fields. Simple knowledge often only requires a small amount of information to be clearly described, while complex knowledge requires a large amount of information to explain it clearly. The greater the complexity of knowledge, the higher the level of professionalism and difficulty of understanding it implies, the higher the demands on the capabilities of both parties in knowledge transfer, and the more difficult the diffusion and absorption of knowledge become (Huan et al., 2017). Jensen and Meckling (1992) explicitly pointed out that the nature of knowledge affects the cost of knowledge transformation. Reed and DeFillippi (1990) also believed that the complexity of knowledge increases the difficulty for knowledge recipients to recognize and understand the knowledge itself, increases the difficulty of knowledge transfer, and thus reduces the efficiency of knowledge transfer. Lakatos (1978), in his scientific research program, proposed that scientific theories have a most basic, unquestionable “hard core” and a “protective belt” composed of auxiliary substances that protect the truth. Once a scientific crisis occurs, it is not the “hard core” that has the problem, but the “protective belt” that needs to be adjusted to ensure the precision and continuity of science (Lakatos,

1978). Thus, with the existence of the disciplinary “hard core” and “protective belt”, interdisciplinary knowledge flow is challenging but full of innovation. Higher education research can also develop its own “hard core” and “protective belt” in this process, but it is more open and inclusive compared to other disciplines. Moreover, due to the existence of knowledge stickiness, the knowledge flow between higher education research and other disciplines is relatively difficult. However, since Education and Educational Research, Management, Sociology, Psychology, and Economics already have intersections or overlaps with the research topics involved in higher education research, these disciplinary “hard cores” can be directly applied in the problem-solving process, hence their knowledge structure exhibits distinct family resemblance characteristics.

5.2.3. Medium Permeability Determines the Interdisciplinary Knowledge Flow in HER

In the interdisciplinary knowledge flow of HER, whether relevant knowledge can be absorbed by HER depends on whether it helps to explain higher education phenomena, reveal the laws of higher education, and solve higher education problems. The more similar the knowledge is to the research topics/problems on which HER focuses, the higher the frequency of the knowledge flow. The same is true for the knowledge diffusion phenomenon in HER; whether the knowledge and principles embedded in HER can make corresponding contributions to other disciplines/fields is a key condition for its interdisciplinary knowledge flow. This aligns with Lewin’s (1947) gatekeeper theory, which posits that information flows along certain channels within gatekeeper-guarded gate areas during the dissemination process, and only information that meets group standards or the gatekeeper’s value specifications can be allowed into the channel for dissemination. Conversely, information that does not meet these criteria is filtered out and cannot enter the organization (Lewin, 1947). Some scholars have found that the more culturally similar the two parties in knowledge flow are, the smoother the knowledge flow will be; on the other hand, the greater the cultural difference between the knowledge receiver and sender, the more difficult it is for knowledge to flow between them (Albert et al., 2022a). Ghoshal and Bartlett (1988) also pointed out that transmission channels and paths are important factors affecting the efficiency of knowledge flow. In addition, Teichler and Sadlak (2000) categorize higher education researchers into six types: discipline-based temporary higher education researchers, discipline-based long-term higher education researchers, theme-based academic higher education researchers, applied higher education researchers (policy researchers, institutional researchers), consultants, and practical reflectors. The different starting and ending points in Teichler and Sadlak (2000) lead to an increasingly pronounced gatekeeper effect.

6. Conclusions and Implications

In the process of interdisciplinary knowledge flow in HER, the spillover amount of knowledge exchange between HER and other disciplines/fields is less than the absorption amount, and the knowledge flow is “knowledge input type”. The phenomenon of “reciprocal assimilation” between HER and other disciplines/fields is significant, and the knowledge network shows the characteristics of “family resemblance”. In addition, interdisciplinary knowledge flow in HER is influenced by three factors, among which, knowledge slope plays a promoting role, knowledge stickiness plays a hindering role, and the flow medium has a “gatekeeper” effect in the process.

HERers need to not only explore higher education issues from an interdisciplinary perspective but also be flexible in their “role positioning”, remove the “functional fixation” of their roles, and conduct an in-depth exploration of higher education research from multiple angles, updating the knowledge structure of higher education research. First, HERers must cultivate an interdisciplinary vision and engage in multidisciplinary and multi-

issue studies. While delving into their own expertise, they should also be able to understand and apply the knowledge and methods of other disciplines, becoming “T-shaped” talents. Only in this way can higher education research problems be placed in a more diverse disciplinary context, expand the communication channels of higher education research, and thus better facilitate the resolution of higher education issues. Second, HERers must engage in the open science movement. UNESCO, in its “Recommendation on Open Science”, provides a definition of open science and emphasizes the importance of open science in enhancing scientific cooperation and information sharing, and in opening up the processes of scientific knowledge creation and dissemination to a broader public (UNESCO, 2021). Open science encompasses all aspects of scientific disciplines and academic practices, mainly based on open scientific knowledge, open science infrastructure, open participation by societal actors, and open dialogue with other knowledge systems (UNESCO, 2021). Therefore, HERers can engage in or establish interdisciplinary research teams, participate in international open science projects, and collaborate with other countries and international organizations through open science platforms. Additionally, they can establish HER think tanks to increase the permeability of research media, reduce the flow barriers caused by knowledge stickiness, and enhance the knowledge slope in the research threshold, thereby promoting the development of HER and solving complex problems. Relevant studies have shown that factors such as the degree of mutual openness between knowledge subjects in the higher education research field, knowledge similarity, scientific research groups, and the cooperative consciousness of organizational institutions significantly affect the flow of knowledge in higher education research (Albert et al., 2022b). Therefore, breaking down disciplinary barriers and promoting scientific research cooperation are important pathways to promote the flow of knowledge in higher education research (Anthony, 2020).

7. Limitations and Future Directions

This study has some limitations. For example, the research data selected in this study came from only 10 journals, which do not completely cover all samples of HER since the new century, and there may be some bias. Additionally, the research adopts the methods and tools of scientometrics to discuss the problem. Although it reveals the characteristics and mechanisms of interdisciplinary knowledge flow in HER to a certain extent, the research still has some defects in the presentation of the results due to the limitations of software and algorithms. Therefore, the next step in the research will not only improve the above shortcomings, but will also continue to deeply explore the principles of interdisciplinary knowledge flow in HER, and carry out detailed exploration of its specific and key situational variables. In addition, a longitudinal study will be conducted to track the characteristics and paths of knowledge flow over time.

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