Diversity of Researchers' Fields of Specialization: An Analysis of Interdisciplinarity

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ABSTRACT

Background. There is growing expectation at university campuses for interdisciplinary research that combines multiple spheres of knowledge to deal with increasingly complex social issues. However, few studies have focused on researchers' attributes because of the challenge of disambiguating researchers' names.

Objectives. We analyze the interdisciplinarity of six fields from two points of view focusing on the diversity of researchers' specializations: the number of researchers' fields of specialization; and the dispersion of the number of researchers among the fields of specialization.

Methods. We investigated the number of different fields of specialization for not only the targeted field as a whole but also for each researcher and article. As for dispersion among the fields of specialization, we calculated Simpson's D and Shannon's H' .

Results. The findings indicate that the targeted 6 fields were progressing in interdisciplinarity. On the other hand, for individual researchers, the number of different fields of specialization tends to decrease with years.

INTRODUCTION

As social issues, such as aging population, become increasingly complex, there is growing expectation for researchers to address these issues using interdisciplinary research that combines multiple spheres of knowledge. Many studies have been conducted on interdisciplinary research. However, most of them are based on article citation analysis focusing on the connections between fields (e.g., Lariviere & Gingras, 2010; Carley & Porter, 2012; Garner, Porter, & Newman, 2014). Because of the issue of name disambiguation, few studies have been performed to investigate the relation with researchers' attributes. In recent years, the increasing adoption of ORCID author identifiers by journal publishers has made it easier to investigate interdisciplinarity based on researcher's attributes. ORCID provides persistent author identifiers and maintains a registry of these identifiers,

Recent studies have tended to focus on diversity (variety, balance and similarity) as an important aspect of interdisciplinarity. Some authors are arguing for the need to define various aspects of interdisciplinarity (e.g., Wang, Thijs, & Glänzel, 2015; Zhang, Rousseau, & Glänzel, 2016). This study examined the progress of interdisciplinarity in six fields, based on the fields of specialization of paper authors—a perspective that has not been fully studied.

METHODOLOGY

Perspectives and Indicators

We analyzed interdisciplinarity from the following two points of view focusing on the diversity of researchers' specializations:

1. Variety—the number of researchers' fields of specialization
2. Balance—the dispersion of the number of researchers among the fields of specialization.

We regard a greater number of researchers' fields and higher dispersion among them as higher interdisciplinarity. We used the number of different fields of specialization V for *variety*; and Simpson's D and Shannon's H' for *balance*. Regarding V , we calculated the indicator for not only the targeted field as a whole, but also for each researcher and article.

Study Targets and Data

This study targeted six fields (informatics, environmental science, mathematics, biomedical engineering, history, and management studies). Informatics and environmental science were chosen as examples of interdisciplinary fields. Mathematics and biomedical engineering are examples of basic and applied fields respectively. History and management studies are examples of humanities and social sciences, respectively. For each field, we chose two of Web of Science (WoS) categories to observe the tendency of each field, and extracted bibliographic data from WoS as follows:

1. For each targeted field, articles published in 1994, 2004, and 2014 were extracted to investigate the change of interdisciplinarity.
2. We regarded the authors of these extracted articles as researchers working in each field.
3. All past articles by these researchers were extracted using the author IDs (ORCID¹ and ResearcherID).
4. We aggregated the WoS categories assigned to the extracted articles for each researcher.

We excluded researchers that could not be identified by author IDs.

The numbers of articles and target researchers are shown in Table 1.

Aggregation Methods

Researchers

First, for each researcher, we sought the number of different fields of specialization, V , on the basis of WoS categories assigned to all past articles. To avoid double counting, we combined similar categories based on a matrix of closeness between categories which was introduced by Porter and Rafols (2009). It ranges from 0 to 1, and higher values imply more similar categories. This study combined categories, considering them to be the same, if their degree of closeness was 0.7 or higher.

Next, for each targeted field, we calculated a trimmed mean value of V ($\bar{V}$), which is robust against the influence of outliers. The trimming rate was set at 20%. We compared the six targeted fields based on $\bar{V}$ for each year.

¹ <https://orcid.org/>

Table 1. Basic attributes of the data

Field	WC	Year	N_{AR}	N_{AU}	N_{APR}
Informatics (IF)	ISLS	1994	5,982	479	6,721
		2004	12,901	2,714	43,701
		2014	3,772	1,042	35,465
	CS	1994	4,313	460	5,954
		2004	20,271	4,309	67,210
		2014	7,588	2,098	90,250
Environmental science (ES)	ES	1994	12,321	1,891	33,507
		2004	20,030	6,924	69,727
		2014	43,300	15,655	753,100
	OC	1994	3,036	678	9,026
		2004	4,215	1,819	42,729
		2014	6,423	2,624	130,936
Mathematics (MA)	MT	1994	19,147	1,882	30,230
		2004	28,578	5,188	106,602
		2014	49,393	6,830	264,766
	MA	1994	7,972	1,003	17,104
		2004	13,257	2,957	62,302
		2014	25,129	4,117	170,650
Biomedical Engineering (BE)	EB	1994	3,132	390	7,879
		2004	5,124	1,898	61,951
		2014	11,482	4,411	263,606
	MB	1994	955	173	3,717
		2004	2,402	907	42,567
		2014	7,410	3,469	256,838
History (HS)	HS	1994	5,400	106	2,409
		2004	6,321	194	4,542
		2014	9,772	534	14,619
	AN	1994	1,483	82	1,235
		2004	1,838	305	8,712
		2014	3,390	731	45,280
Management Studies (MS)	BS	1994	3,472	251	902
		2004	5,679	781	11,732
		2014	9,938	1,580	51,505
	MN	1994	5,094	525	5,032
		2004	7,161	1,723	28,001
		2014	15,131	3,485	111,281

Notes:

- WC – WoS category (ISLS: Information Science & Library Sciences, CS: Computer Science, Theory & Methods, ES: Environmental Science, OC: Oceanography, MT: Mathematics, MA: Mathematics, Applied, EB: Engineering, Biomedical, MB: Materials Science, Biomaterials, HS: History, AN: Anthropology, BS: Business, MN: Management)
- N_{AR} – No. of articles
- N_{AU} – No. of target researchers
- N_{APR} – No. of all past articles

Table 2. The number of different fields of specialization ($\bar{V}$)

		IF	ES	MA	BE	HS	MS
Researcher	1994	3.58	3.43	2.80	3.33	2.82	3.85
	2004	3.29	3.29	2.91	2.96	2.37	3.28
	2014	2.62	3.51	2.66	3.22	2.18	2.69
Article	1994	2.85	2.32	2.03	2.49	1.96	2.35
	2004	2.79	2.32	2.15	2.55	1.95	2.21
	2014	4.63	6.14	4.93	6.15	3.58	4.15
Field	1994	28	63	34	26	25	34
	2004	42	75	44	32	35	41
	2014	37	81	43	36	51	51

$\diamond$ IF $\triangle$ ES ∇ MA $\circ$ BE $\times$ HS $\square$ MS

Figure 1. Plot of the number of different fields of specialization ($\bar{V}$)

Articles

We aggregated V of all authors for each article. When conducting this aggregation, we combined similar categories not only within each author but also among co-authors. We calculated $\bar{V}$ (the mean of V) and compared the six targeted fields based on $\bar{V}$ for each year.

Targeted field as a whole

We aggregated V of all target researchers in each field, combining similar categories. Then, in order to examine the dispersion of the number of researchers among fields of specialization, we calculated and compared Simpson's D and Shannon's H' for the distribution of researchers. A high value of D or H' means that the distribution is less unbalanced. While D has high sensitivity to the part of the distribution with high frequencies, H' is strongly influenced by that with low frequencies. Using both of these indices, we analyzed the tendency of the distribution as a whole.

RESULTS

Variety of Researchers' Fields of Specialization

Table 2 and Figure 1 show the number of researchers' fields of specialization, $V(\bar{V})$, taking each of the researcher, article and field as the unit of aggregation. For individual researchers, the value of V tends to decrease with years. Particularly large reductions in V were observed in Informatics (IF) and Management Studies (MS). On the other hand, for articles and for the whole field, V tends to increase with years. Notable increases were observed in Environmental Science (ES) and Biomedical Engineering (BE) for the former, and in Environmental Science (ES), History (HS), and Management Studies (MS) for the latter.

Mathematics (MA) and History (HS) seemed to have a similar trend in 1994, but this was not observed in 2004. As for 2014, a similar trend was observed for Informatics (IF), Mathematics (MA), and Management Studies (MS).

Balance in the Number of Researchers among Fields

We calculated the dispersion of the number of researchers among the fields of specialization with Shannon's H' and Simpson's D (see Table 3 and Figure 2). No major differences were observed for any indicator both between years and between targeted fields. H' and D showed a weakly increasing tendency in fields other than Informatics (IF) and Management Studies (MS).

CONCLUSION

With regard to articles and the whole field, the variety of researchers' fields of specialization has increased over the years, that is to say, the six fields have been progressing in interdisciplinarity. The results of comparison based on H' and D did not necessarily correspond to each other (e.g., Informatics in 2004 is higher in D but lower in H'). The former has high sensitivity to the part of the distribution with low frequencies (i.e. peripheral fields of specialization), while the latter is sensitive to that with high frequencies (i.e. core fields of specialization). Thus, the evaluation of interdisciplinarity depends on the viewpoint adopted. In future studies, we shall conduct more comprehensive analyses of the various researchers' attributes such as research themes and collaborating partners.

Table 3. The dispersion of the number of researchers among fields of specialization

		IF	ES	MA	BE	HS	MS
H'	1994	2.466	2.454	2.162	2.104	2.350	2.722
	2004	2.253	2.597	2.274	2.080	2.486	2.628
	2014	2.440	2.697	2.339	2.391	2.776	2.620
D	1994	0.864	0.789	0.741	0.753	0.827	0.869
	2004	0.822	0.800	0.766	0.697	0.818	0.870
	2014	0.860	0.843	0.833	0.817	0.897	0.868

Figure 2. Plot of the dispersion of the number of researchers among fields of specialization

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