Characteristics of interdisciplinary research in author keywords appearing in Korean journals

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ABSTRACT

Keywords for academic papers are terms selected and created by the authors, and are, in general, considered a core element that summarizes and represents the papers' content. This research analysed the ways in which the author keywords for academic papers are used in multiple disciplines. The Brillouin index was used for an analysis of interdisciplinarity. As a result, 63.7 percent of the keywords were shown to appear in only one area of study. These cannot be considered keywords with interdisciplinarity, but rather with topic specificity. In addition, the interdisciplinarity degree of 80 percent of the keywords were low, between 0 and 0.499. This indicates that the majority of author keywords for academic papers do not show interdisciplinarity. Meanwhile, certain author keywords had a fairly high interdisciplinarity degree. In this case, they can be seen as topics that are researched in multiple disciplines. It was revealed that the interdisciplinarity degree of author keywords in art/physical education are lower than in the humanities or social sciences. This suggests that the interdisciplinarity of author keywords is lower in art/physical education than in the humanities or social sciences.

Keywords: Interdisciplinarity; Interdisciplinarity degree; Author keywords; Academic papers; Brillouin index

INTRODUCTION

Generally, author keywords in academic papers can be considered as a key element to understand the contents of the paper. Researchers use the phrase author keyword interchangeably with other phrases, such as 'author-keyword', 'author-assigned keywords', 'keyword given by author'; it, however, is commonly defined as 'a term selected by the author of an academic paper and given to the paper in person' (Hartley and Kostoff 2003; Gil-Leiva and Alonso-Arroyo 2007; Strader 2009; Liu and Zhang 2010; Haisheng 2012; Weijing and Ying 2013; Kwon 2014; Lu and Kipp 2014). Because author keywords summarize and represent the topic of a research paper, researchers tend to carefully select terms that are consider the most essential and important in the paper. The reasons for this are that: (a) research colleagues can select papers by rapidly checking author keywords, as they are aware that the author keywords consist of the most essential terms that represent papers; and (b) they can verify related keywords previously unknown to them and use them to expend their searches. In other words, as author keywords for an academic paper facilitate search and classification without accessing its entire content, they can be seen not only as a formal element for paper submission, but also as an essential element for information search. Author keywords also can be used to assist accessing a paper through subject classification as well as word search (Lewison and Cunningham 1991). Surely, the use of controlled vocabularies, such as Medical Subject Headings (MeSH), should be considered for the optimum result. However, MeSH is limited to medical sciences and not used in other

fields. In other words, researchers rarely use a controlled vocabulary when selecting author keywords outside of the medical sciences field. If they were to do so, would it be impossible to represent a topic through author keywords selected from uncontrolled vocabularies rather than controlled ones? When it is assumed, as mentioned earlier, that author keywords among the 'elements based on which users select papers' are important, researchers are likely to intentionally select important, frequently used, and essential keywords in their research fields. In the cases where keywords are extracted from only a few papers, their appearance frequencies are low; hence, which terms are the essential keywords in that specific field would be unknown. However, if the appearance frequencies of author keywords extracted from relatively many papers are analysed, what the essential keywords in the relevant field are would certainly be revealed, and these keywords could be regarded as representing the field. In other words, the author keywords that appear repeatedly in research papers in a specific field can be defined as the major keywords of the field and assumed to suggest its topics.

While some terms appear only in specific fields, others appear across multiple fields. Clearly, the latter case is rare among author keywords for academic papers in a traditional single discipline. It is due to the increase of interdisciplinary literature (Braun and Schubert 2003). which is unlike in the past. Today, the quantity of information and knowledge is increasing more dramatically than ever, and technology advancement and the complexity of social structures are also accelerating. It is, in fact, almost impossible to understand the current society through the scope of traditional single disciplines. To understand contemporary society and address its problems, researchers in each field sometimes apply research methods or theories in collaboration with researchers in other fields through multiple manners of interaction. This trend sometimes results in an outcome that can be newly applied or regarded as the movement of a convergence study or interdisciplinary research. As interdisciplinary research increased, there emerged a need for researching the characteristics and impact of interdisciplinarity in each discipline, for research on interdisciplinary structure makes possible research development, stream, tendency, and prediction (Pfirman and Martin 2010).

Interdisciplinary information can be obtained through an analysis of the co-authors or topics of papers, citations across literature, simultaneous citation analysis, and an analysis of topic words given to papers (Pfirman and Martin 2010). In South Korea, research on interdisciplinarity through citation analysis has been done in only some disciplines thus far (Chung 2012; Park and Jung 2013). In comparison, this research did not limit its target to those disciplines but expanded it to academic papers in the fields of the humanities, social sciences, and art/physical education. In this case, of course, an analysis can be challenging, especially when a method such as citation analysis is used, due to the massive amount of data. Therefore, while expanding the range of disciplines, this research measures the interdisciplinarity of disciplines not through citation analysis, but through the appearance frequencies of author keywords in each discipline. Although this method is different from the traditional methods for measuring interdisciplinarity, it is based on the premise that the author keywords of each paper that discusses a specific topic or problem can represent diverse disciplines or topic areas. In other words, if specific author keywords are used in multiple disciplines, they can also be examined from an interdisciplinary perspective.

Thus far, research conducted in relation to interdisciplinarity has generally focused on specific disciplines, and research papers or works of literature have been the unit of analysis in most cases. This research, however, differs for two reasons. First, the research scope was not limited to a specific discipline but accessed from the perspective of a hierarchical classification of studies. In other words, it did not focus on examining a specific discipline in

relation to other disciplines, but it rather undertook a more macroscopic approach. Second, the unit of analysis was neither research papers nor literature; it was author keywords for academic papers.

In particular, no research has been done on how author keywords for academic papers are used in diverse disciplines. A systematic study is necessary to empirically examine this question. According to the National Research Foundation of Korea, disciplines are classified by and large into 'humanities', 'social sciences', 'natural sciences', 'engineering', 'medical and pharmaceutical science', 'agriculture, fisheries, and oceans', 'art/physical education', and 'complex studies'. This research limits its scope to 'humanities', 'social sciences', and 'art/physical education' and measured interdisciplinarity through author keywords for academic papers in these fields.

The terms used in this paper are author keywords for academic papers. Characteristically, they reflect the topic of the paper they are attached to. Depending on the nature of each term, some reflect the features of a specific discipline and appear only in that discipline, whereas others appear across multiple disciplines. This is defined as 'the interdisciplinarity of author keywords' in this research. The analyses were conducted based on the Brillouin index, which was used in previous research measuring the interdisciplinarity of different disciplines (Steele and Stier 2000; Tang 2004; Huang and Chang 2011; Chang and Huang 2012). In this research, the following questions are examined:

    a) What are the terms with a high interdisciplinary degree in each of the fields of humanities, social sciences, and art/physical education?

    b) What are average of interdisciplinarity degree in each sub-discipline?

    c) How are the degree of interdisciplinarity distributed? How do the distributions of the humanities, social sciences, and art/physical education fields differ from one another?

LITERATURE REVIEW

Interdisciplinarity of Journals

Since author keywords for academic papers are closely related to their topics, it is assumed that they are related to the research that assessed the interdisciplinarity of such papers. The reason for this is that, to determine the interdisciplinarity of a paper, the indices of various topics associated with the paper are calculated (Huang and Chang 2011; Chang and Huang 2012). the author keywords for the paper are also subject to the topics of the field that the paper belongs to.

Interdisciplinarity refers to connections among multiple disciplines. Traditionally, interdisciplinarity has often been verified through an examination of reference citations. As interdisciplinary research has increased over the years, however, various ways of measuring interdisciplinarity are being used (Herring 1999; Steele & Stier 2000; Leydesdorff 2007; Sugimoto 2009; Obermeier and Brauckmann 2010; Lariviere and Gingras 2010; Huang and Chang 2011; Chang and Huang 2012). Typically, two methods have been used for this measurement. The first method uses a citation ratio, which is a method to measure interdisciplinarity based on the percentage of papers citing specific terms. (Lariviere and Gingras 2010) analysed the relationships between the interdisciplinarity of disciplines and research outcomes using research papers as the unit of analysis. They measured interdisciplinarity based on the percentage of references that each paper included that referred to papers in categories (i.e. topical fields) other than its own. The second method

measures interdisciplinarity by using indices, such as the Brillouin index or Betweeness centrality. (Steele and Stier 2000) used the Brillouin index to measure the interdisciplinarity of the environmental science field. Based on their analysis of the relationships between the interdisciplinarity and use rate of the 750 papers published in the journal *Forest Science* between 1984 and 1994, they pointed out the limitations of the COC (citation outside category) method of conventional interdisciplinary research and argued that a diversity index should be applied to improve the method. They particularly emphasized that the Brillouin index among diversity indices had proven to be extremely flexible thus far when applied to diverse samples from many fields.

Research has also been conducted in specific domains to measure interdisciplinarity in various methods. Among them, interdisciplinary research was prolific in Nano science because it is not a new science, but rather an agglomeration of currently conducted advanced research, such as physics, chemistry, biology, computer engineering, and medical science (Braun and Schubert 2003) analysed research papers that included the term 'nano' in their titles published between 1986 and 1995, and (Schummer 2004) examined collaboration patterns among researchers through co-authorship. Wang, Notten and Surpatean (2013) analysed interdisciplinary relationships among the five sub-disciplines of nano science by drawing on the co-word method based on keyword mining.

Among the research conducted to measure interdisciplinarity using indices in the field of library and information science (LIS), (Tang 2004) used the Brillouin index for the first time to measure the interdisciplinarity of LIS, and (Huang and Chang 2011) also used the Brillouin index. (Leydesdorff 2007) used Betweeness centrality in addition to the Brillouin index in order to measure the interdisciplinarity of academic journals. He compared the results of interdisciplinarity measurements in each centrality criterion and revealed that Betweeness centrality is more appropriate than degree centrality or closeness centrality as an interdisciplinarity index.

Author Keywords

Terms that can represent a research paper include not only author keywords, but also terms extracted from the titles, abstracts, and contents. Studies using such extracted terms, and relationships among disciplines have also been examined through network analysis (Marschavova 2005; Cho 2011). However, there are fundamental differences between the keywords used in those studies and author keywords, which are the target of analysis in this research. Because those studies extracted frequently used terms from research papers in a mechanical way, the intentional process of their being 'personally selected and given to papers by their authors' cannot be included at all. Of course, the fact that some terms frequently appeared in research papers indirectly reflects that they are important terms that can represent the paper topics; however, they are different from author keywords selected by researchers and given to the papers personally. In other words, the reason why this research focused on author keywords was that they reflect the researchers' intentions, as they purposefully choose author keywords that are the most 'important' terms to represent their papers.

The importance of author keywords has been emphasized in various studies on them (Taghva et al. 2004; Gross and Taylor 2005; Gil-Leiva and Alonso-Arroyo 2007; Hurt 2010; Lu and Kipp 2014;). (Lu and Kipp 2014) examined search efficiency through an analysis of author keywords and tags in medical journals. (Gil-Leiva and Alonso-Arroyo 2007) compared the author keywords and descriptors of research papers within the INSPEC, CAB, ISTA, and LISA databases. They revealed that almost 46 percent of author keywords appeared in

descriptors. This means that half the author keywords given to papers appear either as they are or in the same form as the descriptors through normalization, and it also suggests the possibility that author keywords can be used as a controlled vocabulary. There is also research on author keywords used by authors or editors (Gbur and Trumbo 1995; Hartley and Kostoff 2003) or on their characteristics as meta-tags (Alimohammadi 2003; Craven 2004). Prior research conducted in relation to author keywords commonly emphasized their importance in research papers and addressed their usability. This implies that specific author keywords selected by researchers, as they believed that the keywords were important, not only represent the topics of the papers but can also be analysed and utilised in various ways. In particular, the analysis of the interdisciplinarity of author keywords in this research can provide a basis for use of author keywords in a broad range.

MATERIALS AND METHOD

The data used in this research are the revised data of the Korea Citation Index (KCI). They refer to 59,120 author keywords, which exclude keywords and author keywords with a single appearance from the 533,862 found in the total of 264,338 research papers published on the KCI of the National Research Foundation of Korea from 2007 to 2011 (80,546 in humanities; 114,706 in social sciences; and 69,086 in art & physical education).

To examine the interdisciplinary characteristics of author keywords, it is necessary to understand the disciplines with which author keywords are associated. However, since the disciplines cannot be directly known, a way of indirectly judging them was used. In other words, structure-wise, author keywords belong to a paper and the paper belongs to a journal. All pf the journals have topic classifications which represent disciplines. Through this structure, the disciplines of author keywords are determined, and the interdisciplinarity of author keywords was measured. Based on the discipline classification table of the National Research Foundation of Korea, the KCI lists 23, 22, and 12 sub-disciplines within the humanities, social sciences, and arts & physical education fields, respectively, as shown in Table 1.

Table 1: Data Summary for this Study

Broad field	Discipline	No. of articles	No of journals	No of article keywords	No of analysis keywords
Humanities	Humanities	3,206	19	11,879	1789
	Lexicography	38	1	177	11
	History	11,297	96	38,390	3525
	Philosophy	5,991	44	16,743	3635
	Religion	1,403	11	5,664	849
	Theology	3,943	27	10,386	2335
	Catholic Theology	344	6	1,640	286
	Confucianism	610	4	1,771	692
	Buddhism	1,067	9	4,086	711
	Linguistics	3,886	17	6,867	1224
	Literature	1,810	7	247	11
	Korean Literature	14,962	86	44,435	8314
	Chinese Literature	5,790	18	3,838	474
	Japanese Literature	5,677	16	7,219	973
	Asian Literature	248	3	1,201	93
	English Literature	6,723	33	10,781	2147

	French Literature	2,109	8	8,324	1474
	German Literature	1,960	11	6,223	1196
	Spanish Literature	107	2	310	11
	Russian Literature	990	5	3,834	705
	Classic Literature	138	1	660	87
	Translation	568	3	906	120
	Other Humanities	7,679	60	26,158	4474
Social sciences	Social Science	4,372	29	15,959	6299
	General Social Science	5,548	36	16,961	6415
	Political Science	4,670	29	12,712	4221
	Economics	6,432	41	14,275	2780
	Agricultural Economics	1,032	4	533	73
	Business Administration	11,666	62	19,150	6702
	Accounting	1,547	10	3,572	797
	Business, Finance	3,395	29	5,300	2538
	Social Science	1,919	29	7,221	2346
	Social Welfare	4,120	25	9,604	2136
	Regional Studies	3,549	29	10,219	1611
	Education	20,836	124	41,060	9428
	Law	18,140	101	53,522	13666
	Public Administration	5,347	29	13,085	5455
	Policy Science	2,534	13	7,078	1082
	Geography	2,243	12	7,721	1304
	Regional Development	2,132	11	5,780	910
	Tourism Science	4,791	12	6,770	1681
	Mass Communication	3,589	22	10,300	2252
	Military Science	228	2	365	11
	Psychology	3,086	18	7,442	1744
	Other Social Science	3,530	25	7,192	1277
Arts & Physical Education (P/E)	Art/PE	4,372	15	1,923	272
	General Arts	5,548	11	5,396	887
	Musicology	4,670	26	4,557	738
	Arts	6,432	32	7,740	1141
	Design	1,032	28	8,884	1787
	Fashion Design	11,666	4	2,113	337
	Fine Arts	1,547	32	1,259	219
	Film Studies	3,395	9	1,297	143
	Theatre Studies	1,919	3	662	71
	Physical Education	4,120	67	7,315	972
	Dance Studies	3,549	9	2,052	327
	General Art/PE	20,836	25	3,104	439

The Brillouin index was selected as a method to measure the interdisciplinarity of author keywords. It has been used to assess the interdisciplinarity of academic journals (Huang and Chang, 2011; Chang and Huang 2012). Initially, it was used as one of the methods to measure alpha diversity indices in ecology. These indices are based on 'diversity', the concept of information theory presented by Shannon and Weaver (Shannon and Weaver 1949). This theory draws on the premise that if diversity is high, uncertainty is high; if diversity is low, uncertainty is also low. Besides the Brillouin Index, the Shannon Weaver Index or the Simson Index can also measure alpha diversity indices. Depending on the target scopes and

purposes, the Evenness index, Dominance, and Richness Index are also measured. To measure multiple indices, substituted values (the target of analysis) should be used only after modifications. A variable concerning the complexity of term topics refers to the number of terms used in a relevant field in relation to the number of terms within all fields. The model is as follows:

Interdisciplinarity degree (Brillouin index:HB)

$$HB = \frac{1}{N} \ln \frac{N!}{n_1! n_2! n_3! \ldots} = \frac{\ln N! - \sum \ln n_i}{N}$$

where N = The number of terms that belong to all fields
             n_i = The number of terms that belong to i field

In this research, the measurement was taken in two cases: one was when terms whose Brillouin index value was 'zero' were included, and the other was when such terms were excluded. This was based on the premise of the fact that the Brillouin index value of a specific term being zero means that it appears only in one discipline and thus indicates that it has no interdisciplinarity or is not interdisciplinary. In other words, if terms whose value is zero are included, the average interdisciplinarity degree of a relevant discipline can be assessed. In contrast, if terms whose value is zero are not included, the average interdisciplinarity degree of interdisciplinary author keywords in a relevant field can be assessed.

FINDINGS

The Interdisciplinarity Degree of each Term
The data used in this research are the revised data of the Korea Citation Index (KCI), which was collected to build STNET (Structural Terminology net). They refer to 59,120 author keywords, which exclude keywords and author keywords with a single appearance from the 533,862 found in the total of 264,338 research papers published on the KCI of the National Research Foundation of Korea from 2007 to 2011 (80,546 in humanities; 114,706 in social sciences; and 69,086 in arts & physical education).

Terms in order of Interdisciplinarity Degree
Among the top 25 terms in all disciplines, the term with the highest index value was 'Japan' (3.16345), followed by 'image' (3.08891), 'globalization' (3.05531), and 'culture' (2.98351). Next, the fields of keywords were examined. There were 10 in the humanities and 15 in the social sciences, and there was no keyword relevant to arts & physical education. Of course, this does not mean that keywords did not appear at all in the field of arts & physical education. Their appearance frequency in this field was relatively low in comparison to the humanities and social sciences. The minimum of the index values is zero, which means that author keywords are used in only one field and indicates that there is no topic complexity. It was revealed that 'body composition' (0.00849) was the term with the lowest value, excepting those terms with an index value of zero. Table 2 presents the findings.

Table 2: Keywords with the Top 25 Interdisciplinarity Degree

Rank	Term	Degree	A/B /G*	Count in Humanities	% Humanities	Count in Social Sciences	% Social Science	Count in Arts & PE	% Arts & PE
1	Japan	3.16345	B	164	35.4%	282	60.9%	17	3.7%
2	Image	3.08891	A	212	45.1%	135	28.7%	123	26.2%
3	Globalization	3.05531	B	146	29.1%	326	64.9%	30	6.0%
4	Culture	2.98351	A	371	61.3%	167	27.6%	67	11.1%
5	Postmodernism	2.98041	A	100	40.8%	75	30.6%	70	28.6%
6	Writing	2.97337	A	219	94.4%	11	4.7%	2	0.9%
7	Multiculturalism	2.85490	B	167	43.7%	204	53.4%	11	2.9%
8	Conflict	2.84810	B	67	32.5%	129	62.6%	10	4.9%
9	Network	2.82240	B	38	16.0%	187	78.6%	13	5.5%
10	China	2.78834	B	298	31.4%	626	65.9%	26	2.7%
11	Korean Wave	2.78247	B	64	37.2%	101	58.7%	7	4.1%
12	Education	2.77665	A	197	55.5%	141	39.7%	17	4.8%
13	Media	2.74508	A	74	47.1%	55	35.0%	28	17.8%
14	Symbol	2.70807	A	132	64.4%	22	10.7%	51	24.9%
15	Power	2.70251	A	99	61.9%	52	32.5%	9	5.6%
16	Publicity	2.69703	B	51	29.1%	96	54.9%	28	16.0%
17	Sustainability	2.69142	B	18	15.0%	86	71.7%	16	13.3%
18	Orientalism	2.68362	A	118	76.1%	23	14.8%	14	9.0%
19	Multicultural Society	2.67976	B	97	30.7%	214	67.7%	5	1.6%
20	America	2.67408	A	63	27.4%	163	70.9%	4	1.7%
21	Value	2.67197	B	43	29.5%	81	55.5%	22	15.1%
22	Religion	2.66749	B	149	68.7%	68	31.3%	0	0.0%
23	Change	2.65037	B	89	71.2%	30	24.0%	6	4.8%
24	Diversity	2.64672	B	55	29.9%	119	64.7%	10	5.4%
25	Environment	2.64550	B	34	26.6%	80	62.5%	14	10.9%
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21770	Practical Arts Education	0.06136	A	1	1.4%	68	98.6%	0	0.0%
21771	Taekwondo	0.04154	G	2	0.5%	10	2.3%	421	97.2%
21772	Body Composition	0.00849	G	0	0.0%	0	0.0%	385	100.0%
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59120	Hippocrates	0	B	2	100.0%	0	0.0%	0	0.0%

* A: Humanities, B: Social Science, G: Art & Physical

Terms in order of the Interdisciplinarity Degree in each Field

The terms in order of interdisciplinarity index value in the fields of the humanities, social sciences, and art/physical education are shown in Table 3. The terms with the highest index value were 'Image' (3.08891) in humanities and 'Japan' (3.16345) in social sciences. It was 'Virtual Reality' (2.38394) in art/physical education. This value, though the highest in the field, was significantly lower than the values in the humanities and social sciences.

Table 3: Top 25 keywords in the Humanities, Social Sciences, and Arts & Physical Education

Rank	Humanities		Rank	Social Science		Rank	Art & Physical Education	
	Term	Degree		Term	Degree		Term	Degree
1	Image	3.08891	1	Japan	3.16345	1	Virtual Reality	2.38394
2	Culture	2.98351	2	Globalization	3.05531	2	Preference	2.26819
3	Post modernism	2.98041	3	Multiculturalism	2.85490	3	Communication	2.19901
4	Writing	2.97337	4	Conflict	2.84810	4	Symbolism	2.18406
5	Education	2.77665	5	Network	2.82240	5	Cultural Product	2.09913
6	Media	2.74508	6	China	2.78834	6	Animation	2.08437
7	Symbol	2.70807	7	Korean Wave	2.78247	7	Lifestyle	2.07568
8	Power	2.70251	8	Publicity	2.69703	8	Brand	2.03623
9	Orientalism	2.68362	9	Sustainability	2.69142	9	Digital	2.02609
10	Religion	2.66749	10	Multicultural Society	2.67976	10	Display	1.92795
11	Change	2.65037	11	America	2.67408	11	Participation	1.91851
12	Reappearance	2.64445	12	Value	2.67197	12	Design	1.88678
13	Communication	2.63657	13	Diversity	2.64672	13	New Media	1.88517
14	Politic	2.60770	14	Environment	2.64550	14	Flexibility	1.88016
15	Communication	2.59279	15	Neoliberalism	2.64251	15	Purchase behaviour	1.87140
16	Cultural Industries	2.58984	16	Multi Culture	2.62955	16	Identity	1.83910
17	History	2.58941	17	Comparative Study	2.61390	17	Character	1.83685
18	Art	2.58181	18	Fusion	2.59919	18	Type	1.83323
19	Movie	2.56885	19	Policy	2.59725	19	Arts Education	1.82657
20	Aesthetics	2.56334	20	Contents	2.58497	20	Characteristic	1.81496
21	Memory	2.55682	21	Individualism	2.57573	21	Aesthetic experience	1.78583
22	Recognition	2.55066	22	Satisfaction	2.57028	22	Deconstruction	1.76501
23	Area	2.55049	23	Case Study	2.56375	23	Museum	1.71753
24	Nationalism	2.54098	24	Cooperation	2.55322	24	Digital Media	1.70420
25	Methodology	2.54095	25	Advertising	2.55226	25	Arts	1.70383
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6053	Christian counselling	0.11889	14231	Learning Attitude	0.09057	880	Fitness	0.07796
6054	Yates	0.10266	14232	Medical care	0.08600	881	Taekwondo	0.04155
6055	Chinese character	0.07693	14233	Practical Arts Education	0.06136	882	Body Composition	0.00849
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19398	Hip-hop	0	35572	Hippocrates	0	3550	Histamine	0

Interdisciplinarity Degree Average in the Humanities

The interdisciplinarity degree average of each sub-discipline in the humanities is shown in Table 4. Some sub-disciplines share the maximum value, 3.16345, and the keyword associated with this value is 'Japan'. This suggests that the author keyword 'Japan' has often been used in the sub-disciplines of the humanities and that research related to 'Japan' has

been conducted. In contrast, the minimum values vary, which indicates that there exist terms with a low topic complexity in each sub-discipline.

Next, the average of each sub-discipline was examined in two cases: one was when terms with an interdisciplinarity degree of 'zero' were included, and the other was when such terms were excluded. In the previous case, the sub-discipline with the highest average was Catholic Theology, and the one with the lowest average was Buddhism. In the latter case, they were Catholic Theology and Translation, respectively.

Table 4: Summary of the Interdisciplinarity Degree of each Sub-discipline in the Humanities

Discipline	Count	Min.	Max	Average (include 0)	Average (exclude 0)
Humanities	1789	0.20189	3.16345	1.03424	1.24178
Lexicography	11	0.39817	1.69950	0.76474	0.93468
History	3525	0.14050	3.16345	0.65505	1.04909
Philosophy	3635	0.13633	3.16345	0.64995	1.12557
Religion	849	0.12776	3.16345	0.78936	1.15149
Theology	2335	0.11889	3.08891	0.71622	1.23788
Catholic Theology	286	0.33513	3.05531	1.18013	1.62268
Confucianism	692	0.06136	3.16345	1.10636	1.20000
Buddhism	711	0.53677	3.16345	0.48284	1.04665
Linguistics	1224	0.13106	3.08891	0.76121	1.05350
Literature	11	0.68024	2.64445	0.88644	1.39298
Korean Literature	8314	0.07693	3.16345	0.49393	0.98172
Chinese Literature	474	0.14021	3.08891	0.94760	1.30192
Japanese Literature	973	0.20625	3.16345	0.81728	1.30792
Asian Literature	93	0.36620	3.08891	0.87140	1.22788
English Literature	2147	0.10266	3.16345	0.55470	1.09061
French Literature	1474	0.20190	3.08891	0.81493	1.36811
German Literature	1196	0.17251	2.98041	0.84514	1.33349
Spanish Literature	11	0.41653	3.08891	0.73989	1.01735
Russian Literature	705	0.24508	3.08891	0.87073	1.35510
Classic Literature	87	0.36430	2.65307	1.00443	1.34439
Translation	120	0.07693	2.74508	0.57363	0.96951
Other Humanities	4474	0.04155	3.16345	0.83658	1.07925

Interdisciplinarity Degree in the Social Sciences

The interdisciplinarity degree of each sub-discipline in the social sciences is shown in Table 5. Some sub-disciplines share the maximum value, 3.16345, and the keyword associated with this value is 'Japan'. This suggests that the author keyword 'Japan' has often been used in the sub-disciplines of the humanities and that research related to 'Japan' has been conducted. In contrast, the minimum values vary, which indicates that there exist terms with a low topic complexity in each sub-discipline.

Next, the average of each sub-discipline was examined in two cases: one was when terms with a degree of 'zero' were included, and the other was when such terms were excluded. In the previous case, the sub-discipline with the highest average was Catholic Theology, and the one with the lowest average was Buddhism. In the latter case, they were Catholic Theology and Translation, respectively.

Table 5: Summary of the Interdisciplinarity Degree of each Sub-discipline in the Social Sciences

Discipline	Count	Min	Max	Average (include 0)	Average (exclude 0)
Social Science	6299	0.04155	3.16345	0.84970	0.83998
General Social Science	6415	0.07964	3.16345	0.90789	0.91907
Political Science	4221	0.09222	3.16345	0.92192	0.97775
Economics	2780	0.14050	3.16345	0.75411	1.05349
Agricultural Economics	73	0.25462	2.78884	0.76324	1.09248
Business Administration	6702	0.09507	3.16345	0.65690	0.83897
Accounting	797	0.23418	3.08881	0.63929	0.93130
Business, Finance	2538	0.04155	3.16345	0.75207	0.86369
Social Science	2346	0.15497	3.16345	1.06024	1.17939
Social Welfare	2136	0.07996	3.16345	0.77429	1.07605
Regional Studies	1611	0.16572	3.16345	0.98441	1.26668
Education	9428	0.04155	3.16345	0.46888	0.96278
Law	13666	0.07942	3.16345	0.29901	0.75143
Public Administration	5455	0.10505	3.16345	0.77573	0.88751
Policy Science	1082	0.16944	3.16345	1.07081	1.26211
Geography	1304	0.12776	3.16345	0.70577	1.23866
Regional Development	910	0.20655	3.16345	0.85864	1.16621
Tourism Science	1681	0.12207	3.16345	0.72187	1.10015
Mass Communication	2252	0.12207	3.16345	0.74615	1.16366
Military Science	11	0.34657	2.74508	1.43268	1.43268
Psychology	1744	0.14642	3.08891	0.73267	1.11015
Other Social Science	1277	0.11889	3.16345	0.98578	1.20463

Some sub-disciplines in the social sciences also share the same maximum value, 3.16345, and the author keyword associated with this value is 'Japan'. This indicates that many studies have been conducted on the topic of 'Japan', even in the social sciences.

Next, the average of each sub-discipline was examined in two cases: one was when terms with degree 'zero' were included, and the other was when such terms were excluded. In the previous case, the sub-discipline with the highest average was Military Science, and the one with the lowest average was Law. In the latter case, they were also Military Science and Law, respectively.

Interdisciplinarity Degree Average in Arts & Physical Education
The interdisciplinarity degree of each sub-discipline in the arts & physical education is shown in Table 6. Some sub-disciplines share the maximum value, 3.16345, and the keyword associated with this value is 'Image'. This suggests that the author keyword 'Image' has often been used in the sub-disciplines of the arts & physical education and that research related to 'Image' has been conducted. In contrast, the minimum values vary, which indicates that there exist terms with a low topic complexity in each sub-discipline.
Next, the average of each sub-discipline was examined in two cases: one was when terms with a degree of 'zero' were included, and the other was when such terms were excluded. In the previous case, the sub-discipline with the highest average was Theatre Studies, and the one with the lowest average was Arts. In the latter case, they Theatre Studies and Musicology, respectively.

Table 6: Summary of the Interdisciplinarity Index of each Sub-discipline in Arts & Physical Education.

Discipline	Count	Min	Max	Average (include 0)	Average (exclude 0)
Art/PE	272	0.04155	2.98041	0.71943	1.15207
General Arts	887	0.11611	3.16415	1.06178	1.30443
Musicology	738	0.22146	3.05331	0.44796	1.15190
Arts	1141	0.14162	3.16415	0.81290	1.25171
Design	1787	0.12207	3.16415	0.74979	1.18573
Fashion Design	337	0.28898	3.16415	0.64519	1.18814
Fine Arts	219	0.31026	3.08891	0.63913	1.21713
Film Studies	143	0.22146	3.08891	0.97714	1.36991
Theatre Studies	71	0.21070	3.08891	1.13580	1.46621
Physical Education	972	0.08849	3.08891	0.73568	1.13504
Dance Studies	327	0.07796	3.08891	0.80060	1.28331
General Art/PE	439	0.00849	3.08891	0.96008	1.35960

The distribution and characteristics of interdisciplinarity degree in each discipline

a) The distributions of interdisciplinarity degree

The Interdisciplinarity degree are between 0 and 3.5. The number of author keywords with a value of zero is 37347 out of 59120 (63.17 percent). This means that they appear in one discipline; they are terms without a term-topic complexity, that is, with no interdisciplinarity. The number of author keywords with a relatively low value, between 0.01 and 0.49, was 10493. In sum, the number of author keywords associated with values between 0 and 0.49 is 47840, and they constitute 80.92 percent of the total. The number of author keywords with a high index value is considerably low. This is because relatively few terms appear across many fields.

An examination of the number of disciplines in which terms in each value range appear revealed that the average in the lower range, between 0.01 and 0.49, is two; the higher index values increases as the number of disciplines does. The average number of disciplines in which the author keyword is associated with the highest range (between 3.0 and 3.49) appeared was as many as 31.25 (Table 7).

b) The Distributions of Interdisciplinarity Degree and Differences among the Disciplines

The distributions of the interdisciplinarity degree in the humanities, social sciences, and arts & physical education are shown in Table 8. In this study, they were examined in two cases: one was when terms with the interdisciplinarity degree of 'zero' were included, and the other was when such terms were excluded. In the former case, the average interdisciplinarity degree of a discipline could be assessed; in the latter case, that of the author keywords with interdisciplinarity could be assessed.

When the averages of the interdisciplinarity degree in each discipline were compared, social sciences was found to be highest (0.26260), followed by the humanities (0.24297) and arts & physical education (0.16111). However, when terms with the interdisciplinarity degree of zero were excluded, the average was highest in the humanities (0.77838), followed by social sciences (0.65629) and arts & physical education (0.64844). This revealed that inclusion or

exclusion of terms with the interdisciplinarity degree of zero makes a difference. Especially, it is notable that the difference between the interdisciplinarity degree of the social sciences and art/physical education is trivial when terms with the interdisciplinarity degree of zero are excluded. The comparison of the number of disciplines in which author keywords were associated with each index range appeared indicates that, in all of the ranges, as the index value increases, the number of disciplines in which author keywords appear also increases; it is the highest in the social sciences, followed by the humanities and art/physical education (Table 8).

Table 7: The Number of Author Keywords and the Average Number of Disciplines in which They Appear in each Degree Range

Degree range	No. of keywords	%	Average no. of disciplines
0	37347	63.17	1
0.01 ~ 0.49	10493	17.75	2.06
0.5 ~ 0.99	7153	12.10	3.35
0.99 ~ 1.49	2762	4.67	6.06
1.50 ~ 1.99	975	1.65	10.46
2.0 ~ 2.49	326	0.55	17.38
2.50 ~ 2.99	58	0.10	26.18
3.0 ~ 3.49	6	0.01	31.25
0 ~ 3.49	59,120	100	13.82

Table 8: Differences among the Disciplines in each Interdisciplinarity Degree Range

Range	Humanities		Social Science		Art & Physical Education	
	No. of keywords	Average no. of disciplines	No. of keywords	Average no. of disciplines	No. of keywords	Average no. of disciplines
0	13343	1.00	21338	1.00	2668	1
0.01 ~ 0.49	2553	1.61	7103	2.02	454	1.46
0.5 ~ 0.99	1942	2.47	4742	3.17	298	2.00
0.99 ~ 1.49	1003	4.10	1634	5.34	88	2.90
1.50 ~ 1.99	389	6.47	547	8.36	33	3.87
2.0 ~ 2.49	139	9.09	176	12.17	9	5.11
2.50 ~ 2.99	28	12.14	29	14.72	0	0
3.0 ~ 3.49	1	15.00	2	17.00	0	0
0 ~ 3.49	19,397	4.61	35,571	7.97	0	0
Avg degree (include 0)		0.24297		0.26260		0.16111
Avg degree (exclude 0)		0.77838		0.65629		0.64844

DISCUSSION

The following analysis points have been made based on the research results. First, among the top 25 keywords, 10 were from the humanities and 15 were from the social sciences; none of them was from arts & physical education. Of course, this does not mean that these keywords did not appear in art/physical education at all; rather, the frequency in this discipline was relatively low in comparison to the humanities and social sciences (Table 2). Second, the examination of the interdisciplinary degree each sub-discipline in the humanities, social sciences, and arts & physical education fields revealed the following results.

In the examination of the interdisciplinary degree of each sub-discipline in the humanities (Table 4), 'Buddhism' showed the greatest average difference between when terms with an interdisciplinarity degree of zero were included and when such terms were excluded. This is because there are a significant number of terms (with a value of zero) pertinent to 'Buddhism' due to the characteristics of the sub-discipline and because these terms rarely appear in other fields. In contrast, there was not a very large average difference in the case of 'Confucianism'. This is because terms pertinent to 'Confucianism', in fact, frequently appear in other areas. It should be noted, however, that this could be unique to South Korea. In South Korea, while 'Confucianism' has been researched as a single discipline, related concepts or terms have also been used as the conceptual and philosophical basis of the humanities and social sciences.

In the examination of the interdisciplinary degree of each sub-discipline in the social sciences, 'Geography' had the largest average difference, which well reflects the characteristics of this field's terms. The sub-discipline that deserves attention in the social science is 'Law' because its average of is low in both cases where terms with the interdisciplinarity degree of zero were included and those where they were excluded. This is because overall terms used in this field are pertinent only to the field itself, i.e. holding term-specificity, rather than being interdisciplinary.

In the examination of the interdisciplinary degree of each sub-discipline in arts & physical education, 'Musicology' had the greatest average difference, which is even larger than 'Buddhism' in the humanities and 'Geography' in the social sciences. This is because terms used in 'Musicology' are distinct from terms used in other fields, and many of them are rarely used in other fields.

Third, the distributions of the interdisciplinarity degree were examined. Terms with the interdisciplinarity degree of zero constitute 63.17 percent of all of the terms. These author keywords can be regarded as subject oriented terms that have field specificity and appear only in relevant fields. Additionally, the fact that 80 percent of all of the terms fell between 0 and 0.499 indicates that the majority of author keywords are field specific and not interdisciplinary (Table 7).

Fourth, differences among the disciplines in each degree range were examined. The author keywords of art/physical education have less interdisciplinarity than those of the humanities or social sciences (Table 8). When the order of interdisciplinarity degree was examined, the top 25 author keywords were associated with the humanities or social sciences (Table 2). When the top 100 author keywords were examined, the keywords from the top to the penultimate rank were associated with the humanities or social sciences; only the last one, 'virtual reality' (2.38394), belongs to arts & physical education. Even in terms of the

distributions of index values, the number of author keywords associated with the high index value range was lower in arts & physical education than in the humanities or social sciences. This suggests that the author keywords of arts & physical education have higher field specificity and lower interdisciplinarity than those of the humanities or social sciences. Taken together, in the case that an author keyword's interdisciplinarity is high, its field specificity, which means it appears only in a specific field, is low because it appears in many fields. In contrast, in the case that an author keyword's interdisciplinarity is low, it appears only in specific fields and thus is considered to have high field specificity.

CONCLUSION

This research is significant in that it examined author keywords commonly used in many disciplines from the aspect of interdisciplinarity. It, however, has several limitations. First, there was no detailed stemming process for the author keywords. Since author keywords are provided by researchers, they are characterised as an uncontrolled vocabulary; multiple terms can mean one thing, and both singular and plural forms can be used in terms of formality. For an accurate analysis, there should be a stemming process that draws on the unity of such various factors. However, the multiplicity of author keywords also means a researcher's intentional intervention. Thus, by using author keywords without modifications, we tried to underline the significance of examining their interdisciplinary characteristics based on the actual researcher's behaviour. Second, data were not equally distributed in each discipline. Some disciplines had more journals and consequently more author keywords than others; in some cases, there was only one journal and a very small number of keywords. This limitation made it challenging to generalise interdisciplinarity among disciplines based on a thorough comparison.

In conclusion, it was revealed that the author keywords of academic journals are not generally interdisciplinary. Only a few author keywords with a high interdisciplinarity degree are assumed to be 'frequently researched' topics. An additional aspect that can be drawn from the analyses is that the question, 'What terms do researchers select to provide as author keywords', was answered. In other words, it can be assumed that most researchers select terms that represent particular fields when they provide author keywords and do not use general terms that are frequently used. However, among the few author keywords (1365, 2.31 percent) that appear in more than 10 disciplines, some had a macro concept and generality that rendered it impossible to identify the disciplines in which they are used; such author keywords include 'history', 'culture', 'education', and 'school'. Why did researchers select these terms as author keywords? On the one hand, these author keywords can be regarded as 'frequently researched topics'; on the other, it is questionable why researchers provide such general terms in a limited space where generally only five author keywords can be entered. Addressing such behaviour by researchers in selecting author keywords will be a meaningful future research topic. Additionally, when a network analysis is applied, it is expected that relationships and interdisciplinary meanings focused on terms could be examined in a field network.

ACKNOWLEDGEMENTS

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