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A Domain Analytic View of Interdisciplinary Studies

Abstract

We perform a domain analysis of two recent volumes, *The Encyclopedia of Interdisciplinarity and Transdisciplinarity*, and *The Handbook of Interdisciplinary Teaching and Administration.* These volumes provide a useful snapshot of a field that is global in scope and draws on scholars with backgrounds in numerous academic fields. We identify most-cited authors, co-citation patterns, and most common publication outlets and dates of citations. One remarkable result is the dominance of publication outlets in the Handbook by one journal. More generally, our results support the idea that there is a shared global conversation but nevertheless a divergence in citation patterns within that global conversation. Our analysis of the most common terms in Abstracts and Keywords supports the general conclusion of one shared conversation, but yet with some notable differences.

1. Introduction

The publication in 2024 of both *The Edward Elgar Encyclopedia of Interdisciplinarity and Transdisciplinarity* (F. Darbellay ed.), and *The Edward Elgar Handbook of Interdisciplinary Teaching and Administration* (R. Szostak, ed.) provides an opportunity to submit the field of interdisciplinary studies to domain analysis. Since that field involves scholars from many countries and many academic backgrounds, who publish in a wide variety of outlets, it is challenging for both newcomers to the field and for seasoned practitioners to get a sense of the contours of the field. These two volumes are each notable for their broad global authorship (There have been other recent books such as Klein and Vienni Baptista, 2022, that also pursue some sort of global treatment of interdisciplinarity, but these others have only a dozen chapters or fewer). Our analysis is naturally informed by the numerous domain analyses by Smiraglia of "ISKO's Bookshelf" (2008, 2011, 2013, 2014, 2017, 2018, 2020, 2022). Yet we adjust this approach to reflect the different nature of these works. Still, we hope to draw comparisons between the results we find in the field of interdisciplinary studies with previous analyses of knowledge organization

Unlike ISKO proceedings or a journal, these two edited volumes reflect the decisions of the two editors regarding who to invite as contributors. Yet both editors purposefully sought a diverse and global set of contributors. Though both began by reaching out to scholars who they knew in the field, both would also invite many authors with whom they had no previous connection. Szostak achieved global coverage through networking (though his African and Australian contributors did not complete their chapters). Darbellay put out formal calls for contributions. The result is contributions from authors from dozens of countries on all continents with a wide array of scholarly backgrounds.

In the next section we provide a very brief history of the field of interdisciplinary studies. The remaining sections then describe our results and compare them as appropriate to analyses of the field of knowledge organization. Though these comparisons should be of particular interest to scholars of KO (as should the method of domain analysis itself), we also hope that the analysis of interdisciplinary studies itself

should be of intrinsic interest to scholars of knowledge organization, an avowedly interdisciplinary field.

2. History of the Field of Interdisciplinary Studies

The modern disciplines emerged in the 18th and 19th centuries. The natural science disciplines began to take shape in the very late 18th century as research universities were created in multiple European countries. Social science disciplines would take shape over the course of the 19th century. As the population of scientists grew, and as universities grew in size, and as the body of scientific understanding expanded, scientists came to specialize in particular subjects. This process was further encouraged in the late 19th century as the link between natural science discovery and industrial innovation strengthened. Though the earliest scholarly journals were generalist, they were joined over time by journals devoted to particular disciplines and then subdisciplines. By the end of the 19th century, then, disciplines had gained three important institutional sources of power: power to hire into university departments, power to decide what to teach in those same departments, and power to decide what was published in disciplinary journals.

Almost from the start of disciplinary specialization, some scholars worried about the downside: that researchers would miss the important connections between fields, as would their students. The Italian thinker Giambattista Vico urged a broader education already in the early 18th century: such calls would be echoed over the next centuries with little impact.

In the United States and elsewhere, influential educational leaders began to push for a broader more interdisciplinary approach to education in the interwar period. One result was “great books” programs that celebrated writings that predated the consolidation of disciplines. Yet there was also an effort (associated with John Dewey among others) to develop courses that would tackle complex problems such as racism by drawing on multiple disciplines.

These efforts intensified in the postwar period, especially with a 1945 study by Harvard University on general education. Thinkers such as Michel Foucault assailed the power of disciplines while others worried about the barriers to communication across disciplines. In the 1960s and 1970s a host of new interdisciplinary programs were created to address societal concerns: gender studies, ethnic and racial studies, area studies, environmental studies, and many more (Repko et al. 2025, Wernli and Darbellay 2017).

The Association for Integrative Studies was created in 1979. It was originally focused on teaching within some dozens of interdisciplinary studies programs in the United States. Over the next decades it would broaden its remit in many ways: it would become interested in questions of administration and later research and policy advice. It would become increasingly international with conferences and presidents from first Canada and then Europe. From the 1990s, several scholars associated with AIS (renamed the Association for Interdisciplinary Studies; https://interdisciplinarystudies.org/) developed textbooks on how to perform interdisciplinary analysis.

There is ongoing debate within the field about how best to define interdisciplinarity. Yet there is considerable consensus that interdisciplinarity generally involves efforts to integrate insights from different disciplines into a more comprehensive understanding. There is also broad recognition that interdisciplinarity usually involves studying

interactions among phenomena studied in different disciplines, and often seeks to integrate across different theories and triangulate between results obtained from different methods. Grappling with terminological differences is also common (see Repko et al. 2025).

As the AIS became more international, several AIS scholars came to interact with associations in other parts of the world. The most notable of these is td-net, a network of transdisciplinary scholars funded by the Swiss government but which has held conferences in several European countries. (Transdisciplinarity for them means interdisciplinarity that not only crosses disciplinary boundaries but draws in expertise from beyond the academy; https://en.transdisciplinarity.ch/.) Integration and Implementation Sciences, a network based in Australia but with global links should also be mentioned (https://i2s.anu.edu.au/). Representatives from these and other organizations have in recent years formed the Global Network for Interdisciplinarity and Transdisciplinarity (https://itd-alliance.org/).

A key motive for the present study is to see whether there is still a tendency for scholars within the global community to cite those with a similar organizational pedigree. Do AIS scholars tend to cite each other, while td-net scholars cite each other also? If so, are there key scholars that bridge these communities? Note that these divisions are not entirely regional. There are European universities that have long interacted with AIS and use textbooks developed within AIS. There are some North Americans with strong links to td-net. Note that both Darbellay and Szostak, the editors of the two volumes under consideration here, have long had connections with all of the organizations noted above, though Szostak is more closely associated with AIS. This is reflected in the two volumes, with AIS members providing about half of the Handbook chapters but only perhaps a fifth of Encyclopedia entries.

3. Citation Identity and Citation Image

Domain analysis is a suite of multi-methods techniques used in knowledge organization to extract ontical evidence from a variety of domains. The methodology has been evolving for thirty years and is most often represented by a combination of informetric techniques, discourse analysis and ethnographic studies (Hjørland 2017; Smiraglia 2015). Following the pattern developed over time for "ISKO's Bookshelf" Smiraglia (2008, 2011, 2013, 2014, 2017, 2018, 2020, 2022) we will use citation analysis to reveal the citation identity (the set of authors cited) and citation image (the set of co-cited authors) of Interdisciplinary Studies. Detailed analysis of the most influential works cited helps flesh out the contexts for understanding the domain. Author co-citation analysis reveals the citation image of the domain. Finally, co-word analysis is used to analyze domain thrust as a form of methodological triangulation with the citation identity and image results.

"Citation identity" is a term used in domain analysis to summarize the overall image of a domain presented through its collective citation practices, in particular the set of authors most frequently cited and the accompanying informetric contexts. "Citation image" is revealed by analyzing the perceptions of domain participants (i.e., citing authors) through visualization of clusters of authors cited together (author co-citation). The analysis that follows builds from simple metrics through a series of network analyses

to reveal the citation identity and citation image of Interdisciplinary Studies that emerged from the two sources at hand.

3.1 Citation Identity: Author Affiliations

We first examined the institutional location of authors. We found a very broad distribution in both volumes: authors come from dozens of different institutions. There are only a handful of institutions that contribute multiple chapters to both volumes. This is most often an artifact of having one or two authors from that institution publishing multiple chapters in both volumes: Szostak, for example, is responsible for all but one of the chapters from the University of Alberta.

The Encyclopedia contains 135 articles; the Handbook contains 27 chapters. We did not calculate the specific numbers of references per chapter; analysis of a journal or of the proceedings of a conference would include that measure as an epistemological indicator, but in reference sources it is considered more a matter of editorial policy. In the Encyclopedia there were 1625 references and in the Handbook there were 1174. Simple means calculation shows that the mean number of references per paper were 12 in the Encyclopedia and 45 in the Handbook. We attribute the differential to divergent editorial policies in the two sources, which is entirely appropriate given their divergent purposes. Note that in our co-citation analysis below we identify more co-citations for the Handbook than for the Encyclopedia simply because the reference lists for Handbook chapters were much longer.

3.2 Citation Identity: Most Cited Authors and Works

In the next four tables, we provide the most cited authors and works for both the Handbook and Encyclopedia. Note that in the "authors" tables, only the first author of a co-authored publication is accounted for.

Table 1: Most Cited Authors, Handbook

Klein	38
Repko	26
Szostak	20
Newell	17
Augsburg	14
Holley	12
Darbellay	11
Vienni Baptista	11
Boix Mansilla	10
Lindvig	9
Carmichael	8
O'Rourke	8

Rashid	8
van Lambalgen	8
McMurtry	7

Table 2: Most Cited Works, Handbook (Number of chapters cited in)

Repko, Allen F. and Rick Szostak. 2020. *Interdisciplinary Research: Process and Theory*, 4th ed. Sage [Multiple editions]	14
Repko, Allen F., Rick Szostak and Michelle Phillips. 2019. *Interdisciplinary Research: Process and Theory*, 3rd ed. Sage [Multiple editions]	7
Klein, Julie Thompson. 1990. *Interdisciplinarity: History, Theory and Practice.* Wayne State University Press.	5
Klein, Julie Thompson and William H. Newell. 1998. "Advancing Interdiciplinary Studies." In William H. Newell, ed. *Interdisciplinarity: Essays from the literature.* College Board,, pp. 3-22.	5
Klein, Julie Thompson. 2010. *Creatng Interdisciplinary Campus Cultures: A Model for Strength and Sustainability.* John Wiley & Sons.	4
Klein, Julie Thompson. 2017. "Typologies of Interdisciplinarity: The Boundary Work of Definition." In Robert Frodeneman, ed., *The Oxford Handbook of Interdisciplinarity*, 2nd ed. Oxford University Press, pp. 21-34.	4
Newell, William H. 2001. "A Theory of Interdisciplinary Studies." *Issues in Integrative Studies* 19, no.1: 1-25.	4
Newell, William H. 2001. "The Promise of Integrative Leraning." *About Campus* 4, no.2: 17-23.	4

Table 3: Most Cited Authors, Encyclopedia

Klein	30
Runco	19
Bammer	15
Pohl	15
Darbellay	11
Hoffmann	10
McGregor	10
Repko	10
OECD	10
Lawrence	9
Defila	8
Plucker	8
Stokols	8
Bergmann	7

Gardner	7
Hall	7
Holley	7
Kuhn	7
Lubart	7
Nicolescu	7
Szostak	7
Vienni-Baptista	7

Table 4: Most Cited Works, Encyclopedia (Number of chapters cited in)

Kuhn, Thmas S. 1962. *The Structure of Scientific Revolutions*. University of Chicago Press. [Multiple editions]	7
Repko, Allen F. and Rick Szostak. 2020. *Interdisciplinary research: Process and Theory*, 4th ed. Sage [Multiple editions]	7
Rittel, Horst W. J and Melvin M. Webber. 1973. "Dilemmas in a General Theory of Planning." *Policy Sciences* 4, no. 2: 155–169.	6
Bammer, Gabriele , Michael O'Rourke, Deborah O'Connell, Linda Neuhauser, Gerald Midgley, Julie Thompson Klein, Nicola J. Grigg, Howard Gadlin, Ian R. Elsum, Marcel Bursztyn, Elizabeth A. Fulton, Christian Pohl, Michael Smithson, Ulli Vilsmaier, Matthias Bergmann, Jill Jaeger, Femke Merkx, Bianca Vienni Baptista, Mark A. Burgman, Daniel H. WalkerJohn Young, Hilary Bradbury, Lynn Crawford, Budi Haryanto, Chaim Pachanee, Merritt Polk and George P. Richardson. 2020. "Expertise in Research Integration and Implementation for Tackling Complex Problems: When is it Needed, Where can it be Found and How can it be Strengthened?" *Palgrave Communications* 6, no. 1: 1–16.	5
Freire, Paulo. [1970] 2000. *Pedagogy of the Oppressed*. Bloomsbury. [Multiple editions]	5
Hoffmann, Sabine, Lisa Deutsch, Julie Thompson Klein and Micahel O'Rourke. 2022. "Integrate the Integrators! A Call for Establishing Academic Careers for Integration Experts." *Humanities and Social Sciences Communications* 9, no. 1: 1–10.	5
Klein, Julie Thompson. 1990. *Interdisciplinarity: Hitory, Theory and Practice.* Wayne State Univerdity Press.	5
Klein, J.ulie Thompson. 2021. *Beyond Interdisciplinarity: Boundary Work, Communication, and Collaboration*. Oxford University Press.	5
Runco, Mark A. and Garrett Jaeger. 2012. "The Standard Definition of Creativity." *Creativity Research Journal* 24: 92–96.	5

A few points stand out from these tables. One commonality is the ubiquity of Julie Thompson Klein. It will surprise nobody long acquainted with the field that she is the most cited author in both works. Notably, she has several different works that receive multiple citations. (This suggests that her citations do not reflect a reputation effect but that she is cited for the importance of these works). Klein produced important works over a period of four decades. She worked closely with both AIS and TD-Net and was one of the founders of the Global Alliance.

Despite Szostak's efforts to attract a global set of authors, some half of Handbook authors are affiliated with AIS. Authors affiliated primarily with AIS – Repko, Newell, Szostak, Augsburg – thus dominate both tables for the Handbook. Repko and Szostak, and Augsburg, have both authored textbooks in the field, and these are highly cited. The

authorship of the Encyclopedia is more diverse and so also are the tables of most-cited works. The AIS authors are now joined by a handful of authors closely allied with td-net: Pohl, Hoffman, and Defila. There are also authors from the "team science" literature such as Stokols and Hall (the transdisciplinarity and team science literatures are linked since transdisciplinary research requires teams), and authors most known for works on creativity: Runco and Lubart. Darbellay is also a scholar of the relationship between creativity and interdisciplinarity; he has been active in both AIS and td-net over the years. Gabriele Bammer, the coordinator of the Australia-based Integration and Implementation Sciences, is cited much more by td-net than AIS scholars (this may reflect in part her focus on research and the Handbook's emphasis on teaching).

There are 210 authors cited twice or more in the Encyclopedia and 128 in the Handbook. The top of the tier is roughly the same in both sources—Klein, Repko, Szostak, Runco, Darbellay—all of the authors in the next tier occur on both lists but in different positions—Bammer, Pohl, Hoffmann, McGregor, Lawrence, Newell, Augsburg, Holley, Vienni Baptista and Boix Mansilla. The raw data on most cited authors thus suggest that there is both an important degree of global commonality and of divergence in citation practices. Some authors are well-cited in both volumes. Other authors fare much better in one volume or the other.

3.3 Citation Identity: Journals

The next most important factor in citation image is the proportion of journal articles cited and consistency in the cluster of those most-cited. 420 journals are cited 718 times in the Encyclopedia; 44% of the citations in the Encyclopedia are to journal articles. 330 journals are cited 607 times in the Handbook; 51% of the citations are to journal articles. Based on the data from these two sources, the domain of Interdisciplinary Studies has a citation image that closely mirrors that of a social scientific domain, with about half of the research cited situated in peer reviewed journals. There are very few citations to papers in conference proceedings, which indicates a domain that is well concretized with theoretical writing in monographs, anthologies and handbooks, and emergent theory in peer-reviewed journals. It is remarkable that the frequencies in the Encyclopedia are more dispersed (or one might say flatter) than in the Handbook (discussed below). The following table provides the most-cited journals in the Handbook.

Table 5: Most Cited Journals, Handbook

Issues in Interdisciplinary Studies (previously Issues in Integrative Studies)	65
Studies in Higher Education	14
Sustainability Science	13
Futures	12
Journal of Higher Education	12
Higher Education Research and Development	11
BioScience	10
Small Group Research	10
Higher Education	8
Research Policy	7
Frontiers; The Interdisciplinary Journal od Study Abroad	7
Minerva	6
Research in Higher Education	6

It is common in many fields, including KO, for one or two journals to dominate citations, the dominance of Issues in this list is still noteworthy. While *Knowledge*

Organization would generally top similar lists in Smiraglia's previous analyses of KO, there would be many citations also to articles in *Cataloging and Classification Quarterly* and more general information science outlets such as *JASIST* and the *Journal of Documentation*. *Issues in Interdisciplinary Studies* stands alone as a venue that focuses on articles *about* interdisciplinarity. Since the field of interdisciplinary studies is not nestled within a larger field in the way that knowledge organization is nestled within information science, authors of works about interdisciplinarity have less obvious recourse to other journals that see interdisciplinarity as among their key areas of concern. Some journals such as *Futures* and *Sustainability Science* have come to see interdisciplinarity as an area of interest, and a handful of higher education journals accept articles about interdisciplinary teaching. (A couple of newer journals such as *Social Science and Humanities Communications* also publish works about interdisciplinarity but they only received two or three citations each here). Nevertheless, the literature in interdisciplinary studies is strewn far more widely than is the knowledge organization literature.

The results for the Encyclopedia are less dramatic. *Issues in Interdisciplinary Studies* gets fewer citations than *Futures*, and some other journals are not far behind. Yet it is still worth noting that none of these other journals take inter/transdisciplinary as a primary focus. These results provide further evidence of citation subgroups within the global community: the Handbook, with a large number of AIS-affiliated scholars, sees large numbers of citations to the AIS-sponsored *Issues in Interdisciplinary Studies.* The Encyclopedia, with a more diverse set of authors, relies less dramatically on *Issues.* Scholars associated with td-net often publish in Futures or environmental journals. There are, of course, some *Issues* citations from non-AIS-affiliated scholars, but these are far less common than *Issues* citations from AIS-affiliated scholars.

Social Science and Humanities Communications receives 8 citations in the Encyclopedia, an impressive total for a newish journal (founded in 2014, received its present title in 2020). It will be interesting to see how citation patterns evolve in future.

Table 6: Most Cited Journals, Encyclopedia

Futures	25
Issues in Interdisciplinary Studies (formerly Issues in Integrative Studies)	18
Creativity Research Journal	17
Environmental Science & Policy	17
Sustainability Science	17
Ecology and Society	16
Nature Sustainability	9
Humanities and Social Sciences Communications	8
Psychology of Aesthetics, Creativity, and the Arts	8
Research Policy	8
GAIA – Ecological Perspectives for Science and Society	7
Sustainability	7
American Journal of Preventative Medicine	6
Journal of Creative Behavior	6
Policy Sciences	6
Transdisciplinary Journal of Engineering & Science	6
Sustainability	6

Collected works other than journals receive far more citations in the Encyclopedia than in the Handbook. This is in large part due to the existence of a set of Handbooks

devoted to transdisciplinarity. Creativity and team science also receive more attention in the Encyclopedia than in the Handbook (though there are chapters on each in the Handbook). Curiously, even some collected works devoted to interdisciplinarity receive more citations in the Encyclopedia than the Handbook. The most remarkable is *Interdisciplinarity: Essays from the Literature*, an AIS-sponsored collection from 1998. It appears that (some) Encyclopedia authors felt a greater need to cite "classic" works. Note that most of the chapters in this collection are reprints of articles from *Issues in Integrative Studies* and thus its influence on the Encyclopedia is greater than the Journal totals in the table above would indicate.

Table 7: Most Cited Collected Works, Encyclopedia

Oxford Handbook of Interdisciplinarity	14
Encyclopedia of Creativity	8
Strategies for Team Science Success	7
Handbook of Transdisciplinarity: Global Perspectives	6
Handbook of Transdisciplinary Research	6
Interdisciplinarity: Essays from the literature	6
Interdisciplinary and transdisciplinary failures: Lessons learned from cautionary tales	5
The Toolbox Dialogue Initiative: The Power of Cross-Disciplinary Practice	5
Transdisciplinarity: Joint problem solving among science, technology, and society	5
Institutionalizing interdisciplinarity and transdisciplinarity. Collaboration across cultures and communities	4
Interdisciplinarity: problems of teaching and research in universities	4
The Palgrave Encyclopedia of the possible	4
The Stanford Encyclopedia of Philosophy	4

3.4 Citation Identity: Dates of Works Cited

There are 1596 works cited with usable dates in the Encyclopedia. The mean age of work cited is 16.75 years. The mode age of work cited is 5 years. The median age of work cited is 10 years. The frequency distribution of year of work cited shows that most works cited are recent: roughly 2019 to 2023.

For the Handbook, there are 1161 works cited with usable dates. The mean age of work cited is 14.57 years. The mode age of work cited is 8 years. The median age of work cited is 11 years. The frequency distribution of year of work cited shows that most works cited are recent but with a larger spread than the encyclopedia: roughly 2014 to 2023.

Foundational work cited is relatively recent, all from the late 20th century to the present and with a mean age between 4 and 16 years; this is another indication that the domain has the characteristics of a social science. Most new research cited is from a small core of journals led by Issues in Interdisciplinary (formerly Integrative) Studies, Futures, Sustainability Science, and Creativity Research Journal.

The distributions with respect to date of citation are broadly similar across the two works, with Handbook authors having a slight tendency to cite slightly older works. Notably, both works fit the pattern of the social sciences: humanists tend to cite older works to a greater extent, and natural scientists tend to focus even more on the most recent literature. We see a pattern in both works of emphasizing works from the last decade but making some reference to "classic" works. Some of the classics are works

about interdisciplinarity, while others, notably Kuhn's work in the study of science, are not.

Table 8: Most Cited Years, Encyclopedia

2020	128
2023	110
2022	100
2021	98
2019	98
2017	86
2018	70
2015	64
2016	57
2014	57

Table 9: Most Cited Years, Handbook

2017	78
2016	75
2020	71
2019	65
2022	62
2009	53
2023	52
2018	49
2015	49
2014	46

3.5 Citation Identity: Publishers

We also looked at the most cited publishers in the Encyclopedia. Note that while the tallies for Springer and Routledge represent citations of many books (on diverse topics), citations to just a couple of books count heavily in the scores for Oxford University Press and Sage. The OECD published a handful of classic works on interdisciplinarity decades ago.

Table 10: Most Cited Publishers, Encyclopedia

Springer	77
Routledge	70
Oxford University Press	40
Sage	30
Palgrave Macmillan (or either)	23
Cambridge University Press	21
University of Chicago Press	17
Edward Elgar	14
Wiley	14
OECD	13

4. Citation Image: Author Co-citation Analysis

Our analysis of co-citations supports the conclusion reached above concerning the most-cited authors. In the Handbook, the domination of the most-cited lists by AIS scholars mean that they also dominate co-citations – but co-citations with Klein are particularly important: Klein/Repko 11; Repko/Szostak 9; Repko/Augsburg 9; Newell/Repko 8; Newell/Klein 6; Boix/-Mansilla/Klein 6; Boix-Mansilla/Repko 6; Szostak/Augsburg 6; Szostak/Klein 5 [Boix-Mansilla is not closely tied to AIS but is based at Harvard and seems better known among AIS scholars.]. We might make special

note of the fact that Repko and Augsburg, author of key textbooks. are co-cited 9 times. In the Encyclopedia the most co-citations are Nicolescu/Klein 5; Pohl/Bammer 4, Hoffman/Pohl 4; Klein/Repko 4; Klein/Bammer 3; Klein/Pohl 3 ; Bergmann/Pohl 3; Bergmann/Hoffman 3; Klein/Vienni-Baptists 3. These are mostly co-citations among td-net scholars such as Pohl, Hoffman, and Bergmann (and Bammer, who we mentioned above). [The Nicolescu/Klein pairing is notable: Nicolescu pursues a quite different meta-theoretical view of transdisciplinarity; Klein is well-known to those who pursue a similar view.] Repko is the only AIS scholar to make this list; after Klein his next most co-citations occur with Szostak (2).

In Figures 1 and 2 we provide a visual representation of the co-citation patterns in both the Encyclopedia and Handbook. We have used VosViewer 1.6.18 for Mac (https://www.vosviewer.com/). VosViewer creates a visualization of clusters and internal networking based on the co-citation data. The visualization is dynamic, which allows the researcher to enhance features that reveal proximity and relationships among the clusters. Interpreting the visualization involved understanding the act of co-citation is trace evidence of a perception of association (theoretical, topical, social or source) among the co-cited authors. It is always important to remember that the visualization shows how the participants in the domain perceive relationships (and therefore not how the authors named relate their own work). Figure 1 shows the visualization of the research front in the Encyclopedia.

The different colors on the diagrams represent co-citation clusters. For the Encyclopedia we see very clearly a td-net cluster in yellow and a mostly-AIS cluster in green (though Vienni-Baptista is not primarily affiliated with AIS). The team-science scholars are in the blue cluster, and the creativity scholars are in the red cluster (though both of these latter clusters also contain others). The Handbook diagram is of course dominated by AIS scholars. It is still noteworthy that the blue grouping captures one of the td-net scholars and three others who have interacted heavily with both AIS and td-net over the years.

We could conceive of the td-net, AIS, team science, and creativity clusters as “invisible colleges”: groups of scholars who interact, read each others work, and attend the same conferences (see Crane 1972; Zuccala 2006; Garcia et al. 2025). Yet these invisible colleges are porous, with much interaction among them.

The size of the framed name indicates the predominance of co-citation. Thus the cluster anchored by Klein might represent a core theoretical cluster. The density of the lines indicates the strength of the network association. The Runco cluster in the Encyclopedia, then, is most distant from the core and is the most loosely associated cluster. This reflects the fact that creativity is often but not always addressed in the chapters in these volumes.

The visualization is much denser for the Handbook, reflecting the larger amount of referencing in the Handbook. Five clusters are visible with the core represented by Repko (green), Klein (red) and Szostak and Augsburg (blue). Newell (yellow) and Carmichael (purple) anchor smaller less proximate clusters. That Carmichael appears to be alone is an artifact of the visualization. Carmichael, whose work is associated with integrative learning, is cited 9 times in the Handbook (but not at all in the Encyclopedia). We can see that this ontical position is perceived to be associated with all of the other clusters,

but not proximate to the anchors of those clusters. This suggests a granular segment of domain intension.

Figure 1 *VosViewer* Visualization of internal author co-citation in the Encyclopedia

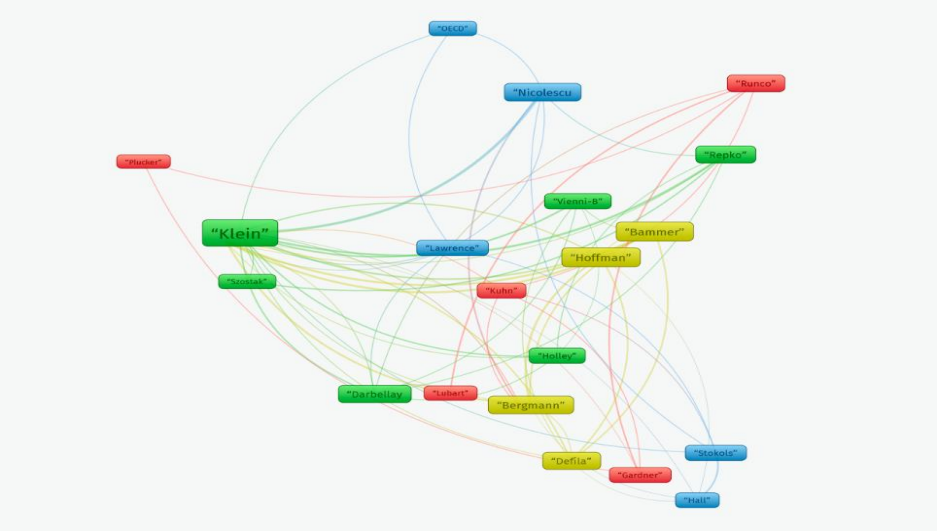
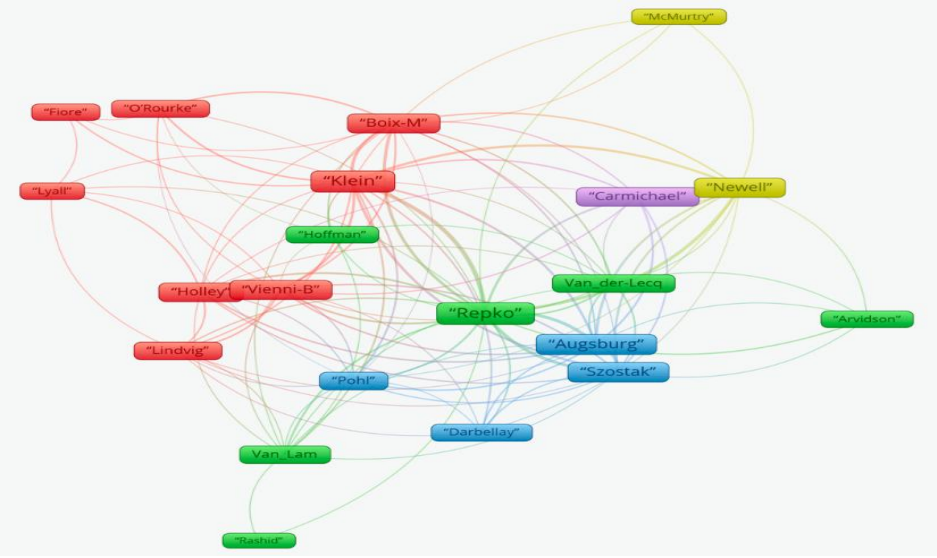


Figure 2 *VosViewer* visualization of internal author co-citation in the Handbook.



5. Domain Thrust through Co-word Analysis

Co-word analysis is a visualization technique used in domain analysis to extract ontical content from trace evidence in a domain. Typically, citation data such as article titles can be used to get a general overview of a domain's ontical content but abstracts and even full texts can be analyzed to reveal richer clusters of meaning, which we call the domain's ontical "thrust." Specifically, co-word analysis uses term frequency and proximity to reveal clusters of terms used in conjunction with each other; proximate terms often constitute a facet. The methodology is described in detail in Smiraglia (2015). Data are entered into the Provalis ProSuite (https://provalisresearch.com/products/prosuite-text-analytics-tools/) using the QDA Miner module, then sorted by frequency and analyzed using the WordStat module. WordStat can be used to produce a three-dimensional visualization of proximity using multi-dimensional scaling (MDS). The resulting MDS visualization, or model, can be adjusted to increase "goodness of fit," in order to produce a statistically reliable model of the data. "Goodness of fit" of the model is given in MDS by stress (which should be low) and R^2 (which should be high); goodness of fit is manipulated by removing singleton clusters until the best possible model is produced.

In general, the analysis proceeds from keywords to multi-word terms or phrases. The step-wise analysis serves as a form of methodological triangulation for the author co-citation analysis, allowing us to view the perceptions of ontical proximity of the participating authors from two different points of view. That is, term clusters in co-word analysis ought to be directly relatable to clusters of authors co-cited for ontical proximity.

We began by analyzing titles from the chapters of the Handbook and the articles of the Encyclopedia. As it happens, in this case the titles were not very helpful. The Handbook's 27 chapter titles contained only 164 words of which 72 were unique (thus, 92 occur more than once). Only 10 terms occurred frequently enough to be usefully mapped; of these "interdisciplinary" and "interdisciplinarity" are the most prominent. 116 2-5 word phrases were detected but only one, "interdisciplinary classroom" occurred more than once. The Encyclopedia's 135 articles mostly bear 1-word titles. These contained 261 words of which 176 are unique (thus only 85 occur more than once). The most frequently occurring words are "science," "Thinking," "design," and "transformative." 10,861 2-5 word "phrases" were detected, of which only 25 occurred 4 times or more. While no useful MDS model could be developed using the Handbook title terms, the Encyclopedia titles generated two not very well-fitting models.

Not surprisingly, the abstracts were a richer data source. The Handbook abstracts contained 3,799 terms of which 913 were unique (2,886 occur more than once) and 2408 23-5 word phrases were identified of which we were able to map 16 that occur 3 or more times. MDS plots of the title keywords and phrases from the Handbook appear in Figures 3 and 4.

Figure 3 (Handbook abstract keywords) is dominated by a large interdisciplinary students cluster in the foreground. Three clusters: insights, integration, team faculty and studies experience orbit the main cluster. Graduate literature is more distant and humanities is quite distant. All of the background clusters represent loose associations. Figure 4 (phrases) is dominated by a large teaching and learning cluster in the foreground, proximate to a larger and more complex interdisciplinary studies cluster.

Blended learning is proximate to teaching and learning, and interdisciplinary curriculum is farther in the background and less proximate.

Figure 3. WordStat MDS visualization of abstract keywords from the Handbook (Stress = 0.15327 R^2 = 0.9804).

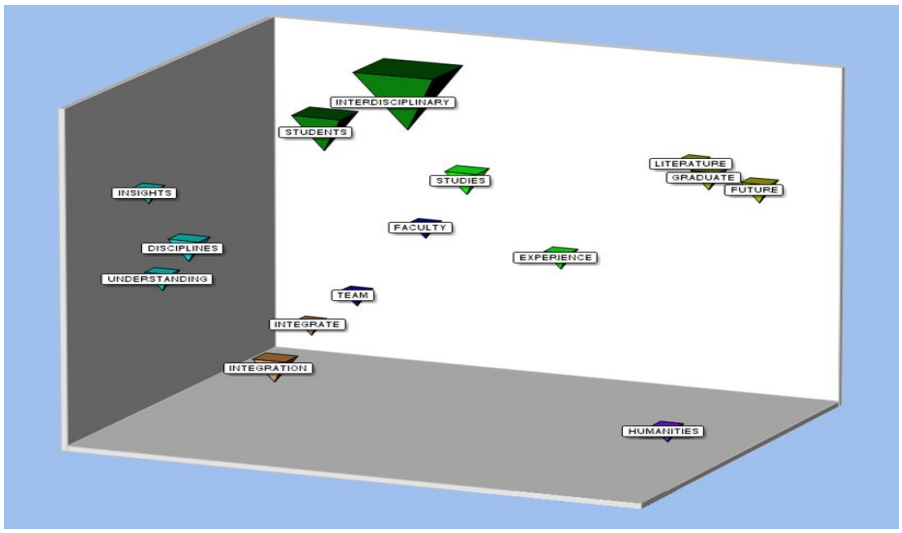
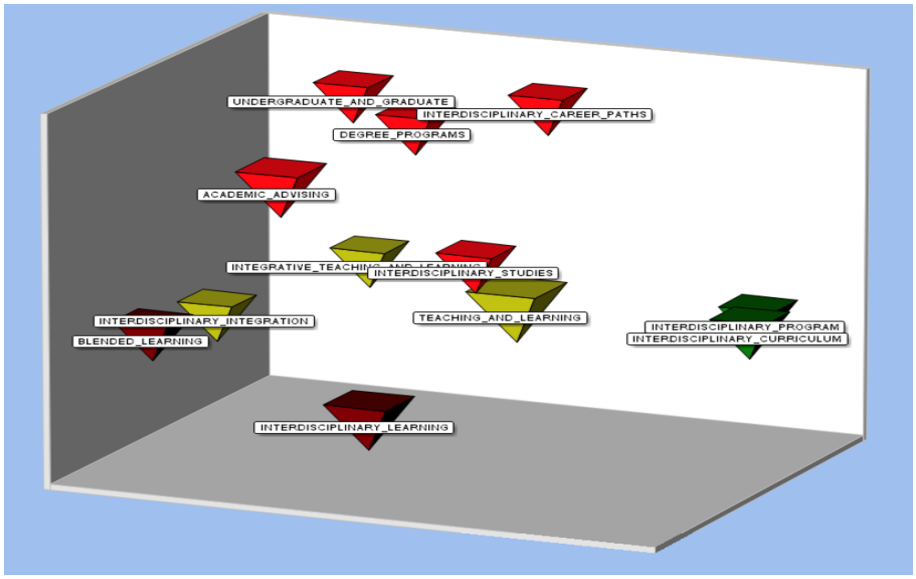


Figure 4. WordStat MDS visualization of abstract phrases from the Handbook (Stress = 0.16386 R^2 = 0.9536).



The Encyclopedia abstracts contained 18,501 terms of which 3,171 were unique (15,330 occur more than once) and 10,861 2-5 word phrases were identified of which we were able to map 64 that occur 3 or more times. MDS plots of the title keywords and phrases from the Handbook appear in Figures 8 and 9.

Figure 5. WordStat MDS visualization of abstract keywords from the Encyclopedia (Stress = 0.22399 R^2 = 0.9548).

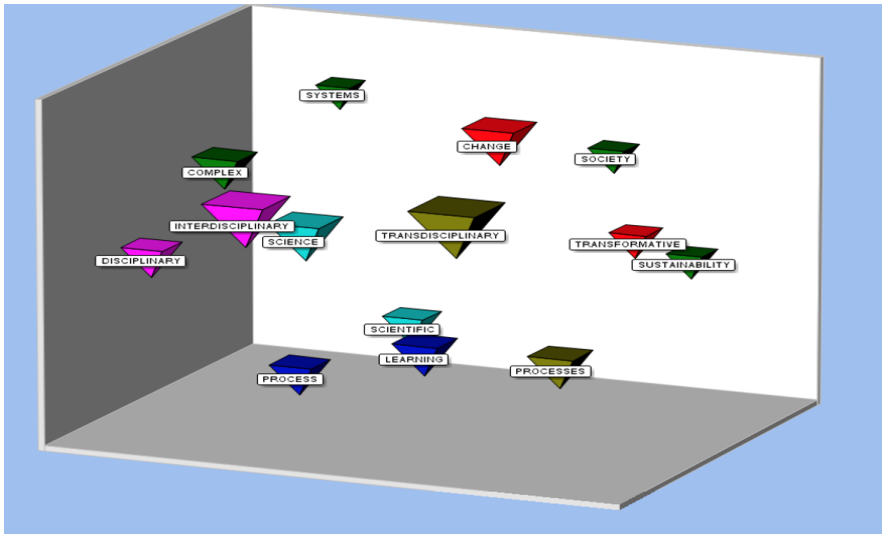
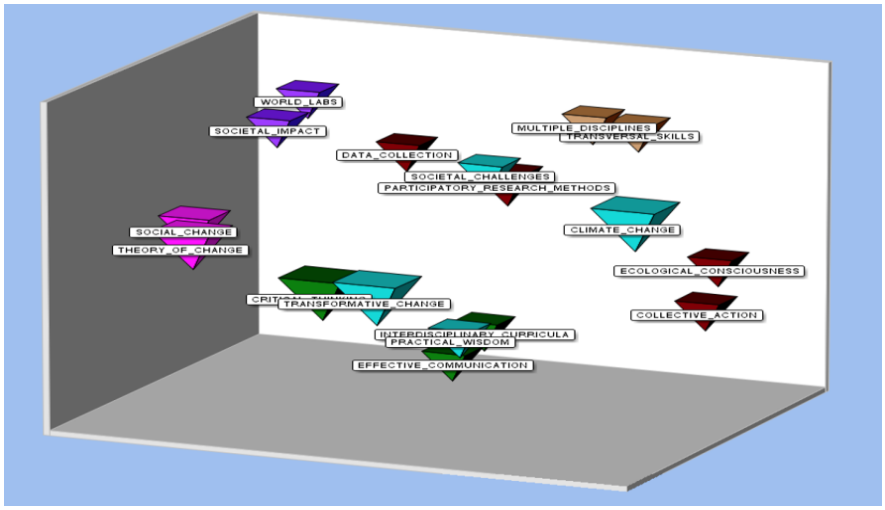


Figure 6. WordStat MDS visualization of abstract phrases from the Encyclopedia (Stress = 0.23641 R^2 = 0.9357).



In Figure 5 (Encyclopedia abstract keywords) we have six clusters: the two most prominent are transdisciplinary processes and interdisciplinary-disciplinary, which occupy the foreground. Complex systems science and learning processes are in the background anchored to interdisciplinary, and transformative change and society sustainability are in the background anchored to transdisciplinarity. Figure 6 (phrases) shows two very proximate, almost overlapping clusters: critical thinking and transformative change. Data collection and participatory research is in the background but proximate to the two main clusters. Around the edges are theory of change and world labs, in the background proximate to critical thinking, and transversal skills and collective action, in the background proximate to transformative change.

Co-word analysis suggests a meta-level ontical core is represented as the domain thrust in these two sources. That is, little granularity emerges such that there is little ontical depth. This likely is due to the editorial policies of the two sources, which after all are designed to represent the domain as a whole at a high level. Specifically, these ontical positions seem to be predominant (and independent of each other, although proximate to varying degrees):

- interdisciplinary
- transdisciplinarity
- participatory action
- social change—theory of change
- integrative teaching and learning
- blended learning
- integrated teams
- complex systems
- transformative change—societal challenges
- practical wisdom—critical thinking

The question then arises whether these represent the domain itself or whether there might be greater granularity if a conference or a set of journals were studied.

Another potential conclusion from the co-word analysis arises from the tendency of interdisciplinarity and transdisciplinarity to take the foreground in tightly bound proximate clusters, and for everything else to be both less proximate (or more distant) and less tightly correlated. This suggests what we saw in the ACA, which is that the perceptions of the co-citing authors is highly dependent on the social influence of invisible colleges, specifically AIS, td-net, etc. This suggests the highly social (or collegial) motivation of domain participants.

Another distinct possibility is that the domain of Interdisciplinary Studies has concretized (Collins 1998), meaning it has settled on that set of ontical positions that can be simultaneously accommodated and sustained. This, too, is largely the result of informal social or collegial action on the part of the domain's clearly influential invisible colleges. Again, analysis of a conference or a set of journals might confirm or reject this hypothesis.

6. Conclusion

The literature on interdisciplinarity is notoriously dispersed. Our analysis of journals and collected works is indicative of this dispersion. With the important exception of *Issues in Interdisciplinary Studies*, scholars publish in a wide array of locations. Though a handful of journals publish multiple works about interdisciplinarity, they tend to have other foci.

One key question is whether there is now one global conversation about interdisciplinarity. Our results provide a guardedly positive answer. There is considerable commonality among most cited authors and works, but also important differences. AIS-affiliated scholars are more likely to cite each other as are td-net-affiliated scholars – but several scholars are well known to both groups. Our analysis of the terms in abstracts and keywords suggests even greater commonality, but still some important differences. It may be that the global community talks about the same things but cites different authors in doing so. Still, one possible divergence bears further scrutiny: scholars of transdisciplinarity likely devote far more attention to how team members interact than scholars of interdisciplinarity that emphasize the cognitive elements of integration.

Our analysis of the dates of works cited suggests that the field behaves like a social science: the vast bulk of citations are to works from the last decade but there are a significant number of citations to classic works both within and beyond the field. Scholars in the Handbook are a little more likely to cite somewhat older works.

We intend to continue the research that we have begun in this paper. We also intend to make our data available. See https://knoworg.org/seventh-domain-analysis-clinic/

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