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## Connecting the Dots: Relation Mapping using Literature Connector and Network Visualization

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## Entire Document

Connecting the Dots: Relation Mapping using Literature Connector and Network Visualization

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### Abstract

Inciteful consists of two different tools for developing our understanding and establishing connection between different research domains. In the present study, Literature Connector (LC) has been used portraying relationship and association between areas of research including subject/topical domains. It provides an interactive visualization showing how they are connected by the literature facilitating interdisciplinary research (IDR). LC identifies the shortest paths between the papers selected for the study by generating an interactive graph, along with search and filters. The study utilized Literature Connector (LC) to assess the association between Sustainable Development Growth 4 (SDG4) with Library and Information Science (LIS). These papers can be processed by the Paper Discovery (PD) tool to find other relevant literature. Both the papers were chosen from dimensions.ai database.

Keywords: Inciteful, Paper Discovery, Literature Connector, Network Mapping, Interdisciplinary Research

1. Introduction The process of searching through academic literature has seen so many advancements including the use of academic search engines (ASE), academic databases (abstracting/indexing as-well-as full-text), web-scale discovery services/systems (WSDS). While these search systems and services have helped researchers in effective information retrieval, the idea of understanding the correlation between two bodies of literature seems to be novel. One dimension of interdisciplinary research or multidisciplinary research (IDR/MDR) could be to discover how two bodies of literature connect to one another. This paper is based on one of the web-app offered by Inciteful which follows a unique approach to provide the most "important" papers in the graph, along with the most similar ones. This similarity measurement is from a class of algorithms called "link prediction" algorithms. Link prediction algorithms are used most commonly in social networks to recommend researchers their potential peers. Inciteful applies the same algorithm for citations credited to the peer(s)/author(s) as suggested by the system. This approach tends to surface more recent literature and helps researchers focus on the state of the art more quickly than if just looking for the top cited papers. The tool used in the present study is Literature Connector (LC). Knowledge is Trans disciplinary and LC tries to find literature connections among different streams and the results may surprise a researcher.

Inciteful pulls data from other projects engaged in coordinating, parsing, and categorizing the academic literature. These projects include Microsoft Academic Graph, Semantic Scholar, Un Paywall, Crossref, and Open Citations. The Microsoft Academic Graph is a heterogeneous graph containing scientific publication records, citation relationships between those publications, as well as authors, institutions, journals, conferences, and fields of study. Semantic Scholar is a project developed at the Allen Institute for Artificial Intelligence, publicly released in November 2015, it is designed to be an AI-backed search engine for academic publications. The project uses a combination of machine learning, natural language processing, and machine vision to add a layer of semantic analysis to the traditional methods of citation analysis, and to extract relevant figures, entities, and venues from papers. In comparison to Google Scholar and PubMed, Semantic

Scholar is designed to highlight the most important and influential papers, and to identify the connections between them (<https://ijlls.org/>), UnPaywall, harvest Open Access content from over 50,000 publishers and repositories, and make it easy to find, track, and use. Crossref makes research outputs easy to find, cite, link, assess, and reuse. Open Citations is an independent infrastructure organization for open scholarship dedicated to the publication of open bibliographic and citation data by the use of Semantic Web (Linked Data) technologies. It is also engaged in advocacy for open citations, particularly in its role as a key founding member of the Initiative for Open Citations (I4OC).

## 2. Literature Connector (LC)

LC works on the algorithm that finds a shortest path from starting point or first paper to second paper in a directed graph based on citations (Bidirectional Search or Shortest Path). It runs two types of simultaneous searches, one towards the starting paper and one backward from the other end of paper and finds connections where these two meet each other in minimum rounds or hops. In each hop LC searches to include papers one level deeper in the graph while comparing both search results to check overlapping. If there are no results found, hop is repeated. The shortest pathways from source to destination are known to pass through overlapping nodes. LC links two networks together and identifies the shortest paths on smaller network once they meet in the middle which reduces the complexity of calculation.

There may be a number of papers which are quite significant from the point of view of citations but their presence in the graph won't showcase a real connection between the papers and make it less productive because of their repeated citations. LC has a Graph Pruning feature that provides the users a unique feature of not pulling the same papers again and again into the graph. Although these papers remain present in the graph with citations. This feature controls the dominating effect of a particularly highly cited paper on overall graph. The Graph Filters available in LC include Keywords and Authors. These filters directly work with the keywords present in the title of a seed paper. Through the Time Management feature, LC provides a user the flexibility of choosing particular years of publication. One can apply the time filters and the graph will highlight the papers published during that selected period again keeping the other important papers in graph. LC also gives the flexibility of extending the path by an extra level of three hops in addition to the paths of two hops (Extended Graphs). This provides a better understanding of how these papers are connected to each other.

## 3. Scope of the Study:

The United Nations' 2030

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<https://sdg4education2030.org/the-goal>

Agenda for Sustainable Development is "a plan of action for people, planet and prosperity". It comprises of 17 Sustainable Development Goals (SDGs). These goals are indivisible and encompass economic, social and environmental dimensions. Sustainable Development Goal 4 (SDG4) is the education goal aiming to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" ([\[education2030.org/the-goal\]\(https://sdg4education2030.org/the-goal\)\). The study utilizes Literature Connector feature to assess the association between Sustainable Development Growth 4 \(SDG4\) with Library and Information Science \(LIS\), a broad academic discipline along with several theories, principles, perspectives and methods. LIS aims to examine all aspects of creation, organisation, management, communication and use of recorded information in all kinds of documents. It deals with the analysis, collection, classification, organisation, preservation, storage, retrieval, movement, and dissemination of information and information resources to avail published information organized and accessible \(Galvin, T. J\).](https://sdg4</a></p></div><div data-bbox=)

## 4. Research Methodology:

Inciteful consists of two different tools to develop understanding and to establish connection between different research domains. The other tool, called Literature Connector (LC), has been used in this study as it bridges two subject/topical domains facilitating interdisciplinary research (IDR). It provides an interactive visualization showing how they are connected by the literature. When two papers are entered it shows the shortest paths between the papers which allows to with the graph, as well as search and filter through the papers. Then send those papers over to the Discovery tool to find other relevant literature to explore literature connection between articles published in two different streams. Both the articles were chosen from dimensions.ai, popular for covering millions of research data.

## 5. Results and Discussion:

The first subject domain was Library and Information Studies and second was Quality Education (SDG4). The article chosen from Library and Information Studies (LIS) was entitled as "Learning as Transformation: Critical Perspectives on a Theory in Progress", by Jack Mezirow in 2000. The second article chosen from Quality Education (Sustainable Development Growth) entitled as "Active Learning Increases Student Performance in Science, Engineering, and Mathematics" authored by Scott Freeman, Mary, Pat Wenderoth in 2014.

Table 1: Details of selected papers

Paper-1	Paper2	Title	Learning as Transformation: Critical Perspectives on a Theory in Progress	Active Learning Increases Student Performance in Science, Engineering, and Mathematics	Discipline	Library and Information Science (LIS)	Quality Education (SDG4)	Authors	Jack Mezirow
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Scott Freeman, Mary, Pat Wenderoth

Year of Pub.

2000

2014

Pub. Journal

The Journal of Academic Librarianship

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Proceedings of the National Academy of Sciences of the United States of America

Cited by

1253

4099

Citing

3

247

Open Access

No

Yes

The table above represents the details of two articles chosen for the study, from two different disciplines LIS and SDG4 respectively. It is observed that the second article from SDG4 gets more citations than article one from LIS. On the basis of the above result, it can be said that open access journals provide better exposure. Fig. 1: Graphical Presentation by LC Comment1063614876 Comment1886755343

5.1 Path Visualization: The stats in the figure shows graph of all of the shortest paths. The size of each of the nodes in the graph is directly proportionate to the number of paths that pass through that node. So, the larger the node, the more central it is to the graph. Each of the nodes in the graph is interactive and allows the user to learn more about the papers by clicking on them. A full screen mode button is available on the top right that gives best interplay between the table and the graph. In the above image, it is a depth 3 graph in which 78724 papers were searched through connector and total 205 papers were found in path. A link has been established on the basis of citations. Two different articles find connection in between only when one has cited the other. Literature Connector has scanned the shortest paths, in three trials between two articles. It has utilised the incredibly fast database originally built for the Paper Discovery tool to present the result in the fastest way than any other tool available.

The keywords used by LC to retrieve similar papers include: Learning, Education, Students, Teaching, Active, Transformative, Developing, Courses, Undergraduate, Engagement, Research, Experience, Effectiveness, Teacher and

Practices (Fig.2).

Fig. 2 Keyword infographics Comment931488967

Table 2: Connecting Papers

SN	Title of Paper/Book	First author	Second author	Year of publication	Journal/ Publisher	Paths	Distance	1
1	Transformational Teaching: Theoretical Underpinnings, Basic Principles, and Core Methods	George M Slavich	Philip G Zimbardo	2012	Educational Psychology Review	62	1 2	Mind in society Lev Vygotsky Michael, Cole 1978 Harvard university Press
2	Adult learning theories: Implications for learning and teaching in medical education: AMEE Guide No. 83	David C. M. Taylor	HossamHamdy	2013	Medical Teacher	7	1 4	Does Active Learning Work? A Review of the Research
3	Active learning: creating excitement in the classroom	Charles C. Bonwell	James A. Eison	1991	Wiley	7	2 6	A review of affective chemistry education research and its implications for future research
4	A review of affective chemistry education research and its implications for future research	A. A. Flaherty	NA	2020	Chemistry Education Research and Practice	5	1 7	Experiential learning: AMEE Guide No. 63
5	Stakeholder Views of Nanosilver Linings: Macroethics Education and Automated Text Analysis Through Participatory Governance Role Play in a Workshop Format	Joshua Dempsey	Kathleen Eggleston	2017	Science and Engineering Ethics	5	1 9	Digest of Education Statistics
6	Digest of Education Statistics	Thomas D, Synder	Sally A. Dillow	1994	Digest of Education Statistics	8	2 10	The Language and Thought of the Child
7	The Language and Thought of the Child	Jean Piaget	NA	1926	London, K Paul, Trench,Trubner & Co.	2	4	

The table above is generated with the help of a set of filters. Filters such as locking the desired paper, can be applied to reduce the size of table to focus on more interesting papers. The graph above will reflect your choices by graying out the papers which have been filtered. This allows for a quicker visual understanding of how the different topics/papers are clustered. Path describes the number of papers present in the loop and distance shows the number of hoops or rounds taken by LC to find the connection between these. Table 3: Seed Papers/ Locked papers

SN Title of paper First author Year of publication Cited by Citing 1

Faculty Development to Address the Achievement Gap Donald L. Gillian-Daniel 2015 5 21 2

Knowledge gain and behavioral change in citizen-science programs. Rebecca C Jordan 2011 252 22 3 Measuring the Outcomes of a Participatory Research Study: Findings from an Environmental Epidemiological Study in Kaunas City Regina Grazuleviciene 2021 0 45 4 Impact Of Teacher Perceptions on Instructional Practices in Alternative Public High Schools Stacy A. Miller 2018 0 63 5 An exploration of teaching strategies in teaching area and perimeter in grade 6 at Mahlabathini Circuit Management Centre. Celenkosini Henry. Madide 2018 0 82 6 First-Generation College Students as Academic Learners: A Systematic Review Jillian Ives 2020 13 127 7 Reflections on integrating the political into environmental education through problem-based learning and political ecology Nick Kirsop-Taylor 2020 2 43

In the above table, seven desired papers are locked and the information regarding their first author, year of publication, cited by, and citations is generated with the help of Inciteful. After locking, the size of the table is reduced to have a clear idea to focus on desired papers. Fig 3: Graphical Presentation after Locking Papers

Figure 3 is a graphical representation of seven desired papers after locking.

Table 4: Most Important Papers

SN Title of paper First author

Page rank

Number of cited by

Year of publication

1

Digest of Education Statistics Sally A. Dillow 0.083069 6538 1994 2 Active learning: creating excitement in the classroom Charles C. Bonwell 0.03633 4208 1991 3 Health professionals for a new century: transforming education to strengthen health systems in an interdependent world Julio Frenk 0.03507 3679 2010 4 Active learning increases student performance in science, engineering, and mathematics Scott Freeman 0.02526 4024 2014 5 Learning as Transformation: Critical Perspectives on a Theory in Progress Joseph, Gillian. M 0.00826 43 2001 6 Learning as Transformation: Critical Perspectives on a Theory in Progress Susan Sisola 0.00789 1410 2004 7 Mastering the Techniques of Teaching Joseph

Lowman 0.00705 53 1984 8 Seven Principles for Good Practice in Undergraduate Education Arthur W. Chickering 0.00648 541 1987 9 Does Active Learning Work? A Review of the Research Michael J. Prince 0.00582 1414 2004 10 Using the Pause Procedure to Enhance Lecture Recall Kathy L. Ruhl 0.00548 112 1987

The table above represents the "most cited papers" according to Pagerank. It can be observed that the most-cited paper attributed to Sally A. Dillow is a 1994 paper entitled "Digest of Education Statistics" with 6538 citations of its own followed by Charles C. Bonwell's 1991 article "Active learning: creating excitement in the classroom" with 4208 citations and Julio Frenk's paper "Health professionals for a new century: transforming education to strengthen health systems in an interdependent world". The least cited paper was authored by Joseph Lowman in the year 1984 with 53 citations. The above-mentioned papers were published between 1984-2014 (for a span of 20 years) which indicates the year-old connection amongst the papers published during different years. Table 5: Recent Papers by the top 10 authors

SN	Title of Paper	First Author	Academic Adar	Published year	Cited by	1
1	Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math	Elli J Theobald	0.120481	2020	76	2
2	Closing the Achievement Gap in a Large Introductory Course by Balancing Reduced In-Person Contact with Increased Course Structure	Sat Gavassa	0.120481	2019	6	3
3	Expertise in University Teaching & the Implications for Teaching Effectiveness, Evaluation & Training	Carl Edwin Wieman				

4	Demographic gaps or preparation gaps: The large impact of incoming preparation on performance of students in introductory physics	Shima Salehi	0.120481	2019	3	4
5	True Grit: Passion and persistence make an innovative course design work	Anne M Casper	0.120481	2019	3	5
6	Weed-Out Classes and Their Consequences	Timothy J. Weston	0.120481	2019	1	6
7	Demystifying the Meaning of Active Learning in Postsecondary Biology Education.	Emily P Driessen	0.120481	2020	6	7
8	Beyond linear regression: A reference for analyzing common data types in discipline-based education research	Elli J. Theobald	0.120481	2019	2	8
9	"What Will I Experience in My College STEM Courses?" An Investigation of Student Predictions about Instructional Practices in Introductory Courses.	Clara L Meaders	0.120481	2019	2	9
10	Through the Eyes of Faculty: Using Personas as a Tool for Learner-Centered Professional Development	Patricia Zagallo	0.120481	2019	1	10

Table 5 exhibits 10 recent papers written by top 10 authors in the chosen disciplines. Literature connector has shown latest as well as previous work connecting two separate disciplines. This table also shows Academic Adar which is a link prediction algorithm based on Bibliographic coupling and co-citation to explore the similarity between papers. Table 6: Most Important Recent Papers

SN Title of paper First Author Published year Cited by Pagerank 1

1	Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom	Louis Deslauriers	2019	87	0.000259
2	Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math	Elli J Theobald	2020	76	0.000187
3	Evaluating Coding Decisions	Jack L. Vevea	2019	3	0.000114
4	Scientific Communication and Literature on the Prize: Inquiry Approaches in Undergraduate Mathematics	Howard D. White	2019	2	0.00011
5	Despite Similar Perceptions and Attitudes, Postbaccalaureate Students Outperform in Introductory Biology and Chemistry Courses	Sandra L. Laursen	2019	20	0.000096
6	Shortlidge, 2019	Erin E. Shortlidge	2019	6	0.00005
7	The Concept of Active Learning and the Measurement of Learning Outcomes: A Review of Research in Engineering Higher Education	Susanna Hartikainen	2019	12	0.000044
8	Professional learning opportunities in a practice-based teacher education programme about the concept of function	Alessandro Ribeiro	2019	5	0.000044
9	Transformative learning as pedagogy for the health professions: a scoping review	Susan C Van Schalkwyk	2019	10	0.000044
10	The Evolution of Charter School Quality	Patrick Baude	2019	5	0.000041

Table above highlights the most important recent papers published between the years 2019 and 2020. The paper with the highest Pagerank value is considered the most important paper. The ranking has been done on the basis of PageRank values. The article "Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom" by Louis Deslaurier has been given highest importance. It is interesting to note that Pagerank is not done on the basis of the citation received.

Table 7: Top Authors Comment645727725 Comment1605471853

SN	Author	No. of papers	Total page rank
1	Sally A. Dillow	1	0.02769
2	Thomas	1	0.02769
3	Charles C. Bonwell	6	0.020917
4	James A. Eison	4	0.02022
5	Julio Frenk	19	0.012288
6	Thomas D. Snyder	2	0.004659
7	Snyder	1	0.004615
8	Nigel Crisp		

9 0.001168 9 Yang ke 5 0.00071 10 Ariel Pablos-Mendez 6 0.000703

The above table shows top authors in the network of the selected disciplines. The ranking has been done on the basis of page rank. The table reflects that Sally A. Dillow holds the top position with only one paper followed by Thomas and Charles C. Bonwell. It is interesting to note that Julio Frenk is in the 5th rank with maximum publications (19) and Ariel Pablos-Mendez is in tenth rank with 6 papers.

Table 8: Top Journals

SN	Journal	Total page rank	No. of papers
1	The Lancet	0.047244	86
2	Proceedings of the National Academy of Sciences	0.026042	11
3	American Journal of Physics	0.013918	26
4	Medical Teacher	0.013678	186
5	Medical Education	0.011872	114
6	Journal of Engineering Education	0.009089	30
7	Academic Medicine	0.008987	113
8	journal of Physical Therapy	0.007944	4
9	CBE Life Sciences Education	0.00775	131
10	Review of Educational Research	0.007696	25

The above table enumerate the most relevant top ten journals retrieved by further processing the LC map for two research papers selected in areas of Library and Information Science (LIS) and Quality Education (UN SDG4). This ranking algorithm is based on the page rank.

## 6. Conclusion:

The Literature Connector is a tool that attempts to connect two academic papers together using citations as the links between papers. It then highlights the paths it found between those papers and allows you to explore, filter, and dive deeper into the papers found along the paths. The problem traditional tools are that they are only able to do a search one or two levels deep in the graph. LC is for interdisciplinary scholars or those moving into a new research area who are curious how their new domain connects to their old one. LC assists an author to explore the most important, similar, relevant publications along with their pagerank, and the details of authors working in a related discipline, and the journals where related research has already been published. It allows an author to expand the scope of his research and obtain more precise results in the desired field. These papers can be analysed further using the Paper Discovery (PD) tool to find the most relevant literature faster. The study found LC an effective tool to establish connections between disparate ideas that might get unnoticed.

7. Acknowledgement: The authors express their sincere gratitude to Inciteful for giving the permission to use their web application available at (<https://inciteful.xyz>).

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- vi)

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Comment1605471853 Done Comment1886755343 Done Comment931488967 figure name

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<b>3/5</b>	<b>SUBMITTED TEXT</b>	59 WORDS	<b>92% MATCHING TEXT</b>	59 WORDS		
<table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>Agenda for Sustainable Development is "a plan of action for people, planet and prosperity". It comprises of 17 Sustainable Development Goals (SDGs). These goals are indivisible and encompass economic, social and environmental dimensions. Sustainable Development Goal 4 (SDG4) is the education goal aiming to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (<a href="https://sdg4">https://sdg4</a></p> <p><b>W</b> <a href="https://sdg4education2030.org/the-goal">https://sdg4education2030.org/the-goal</a></p> </td> <td style="width: 50%; vertical-align: top;"> <p>Agenda for Sustainable Development The Agenda is "a plan of action for people, planet and prosperity". It comprises of 17 Sustainable Development Goals (SDGs). These goals are indivisible and encompass economic, social and environmental dimensions. Sustainable Development Goal 4 (SDG 4) is the education goal It to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." SDG 4</p> </td> </tr> </table>					<p>Agenda for Sustainable Development is "a plan of action for people, planet and prosperity". It comprises of 17 Sustainable Development Goals (SDGs). These goals are indivisible and encompass economic, social and environmental dimensions. Sustainable Development Goal 4 (SDG4) is the education goal aiming to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (<a href="https://sdg4">https://sdg4</a></p> <p><b>W</b> <a href="https://sdg4education2030.org/the-goal">https://sdg4education2030.org/the-goal</a></p>	<p>Agenda for Sustainable Development The Agenda is "a plan of action for people, planet and prosperity". It comprises of 17 Sustainable Development Goals (SDGs). These goals are indivisible and encompass economic, social and environmental dimensions. Sustainable Development Goal 4 (SDG 4) is the education goal It to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." SDG 4</p>
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<b>5/5</b>	<b>SUBMITTED TEXT</b>	13 WORDS	<b>100% MATCHING TEXT</b>	13 WORDS		
<table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>Proceedings of the National Academy of Sciences of the United States of America</p> <p><b>W</b> <a href="https://eber.uek.krakow.pl/index.php/eber/issue/view/28/58">https://eber.uek.krakow.pl/index.php/eber/issue/view/28/58</a></p> </td> <td style="width: 50%; vertical-align: top;"> <p>Proceedings of the National Academy of Sciences of the United States of America, 108(49), 19,540-19,545.</p> </td> </tr> </table>					<p>Proceedings of the National Academy of Sciences of the United States of America</p> <p><b>W</b> <a href="https://eber.uek.krakow.pl/index.php/eber/issue/view/28/58">https://eber.uek.krakow.pl/index.php/eber/issue/view/28/58</a></p>	<p>Proceedings of the National Academy of Sciences of the United States of America, 108(49), 19,540-19,545.</p>
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Sustainable Development Goal 4 (SDG 4) | Education within the 2030 Agenda for Sustainable Development. (2022).

Sustainable Development Goal 4 (SDG 4) | Education within the 2030 Agenda for Sustainable Development

**W** <https://sdg4education2030.org/the-goal>