

This is an electronic reprint of the original article. This reprint may differ from the original in pagination and typographic detail.

Please cite the original version: Santonen, T. (2021) Clarifying terminology for collaborative innovation and development. In Iain Bitran ; Steffen Conn ; Chris Gernreich ; Eelko Huizingh ; Marko Torkkeli & Jialei Yang (Eds.) ISPIM Innovation Conference: Innovating our common future, Proceedings ISPIM Berlin 2021.

Clarifying terminology for collaborative innovation and development

Teemu Santonen

Laurea University of Applied Sciences,
Vanha maantie 9, O2650 Espoo, Finland.
E-mail: teemu.santonen@laurea.fi

Abstract: Over the years a great variety of collaborative innovation concepts and methodologies with varying names, conflicting and overlapping definitions have been presented. In this study collaborative innovation related term variations are identified by utilizing cross disciplinary literature review and snowballing sampling approaches. Visual text analysis is conducted by creating semantic network between the identified terms. The dominating terms are identified by evaluating the popularity of the scanned terms based on the number of publications associated with the terms in Web of Science (WoS) and Google Scholar (GS). As a result, a total of 97 different terms formed on the basis of 67 different words were identified. The top 20 most popular terms based on WoS and GS title search results are presented. The semantic connections between the terms are visualized including nodes sizes based on degree centrality and terms popularity as well as grouping based on Louvain method.

Keywords: collaborative innovation, literature review, semantic network analysis, participatory; community; citizen; public; crowd, engagement, participation

1 Introduction

The confusion relating parallel and overlapping terminology is one of the key problems in many scientific research domains. This phenomenon can easily lead to a risk of not recognizing studies conducted under another terminology or research domain even if the studies could be highly relevant (e.g. Garcia & Calantone, 2002). The innovation research community is not immune to this phenomenon. For example, numerous overlapping radical innovation terms have been coined even if the terms definitions are grounded on identical attributes (Santonen et al. 2016).

Collaborative innovation – a concept associated with the process of engaging various stakeholders to innovate collaboratively – has in recent years gained increasing interest (e.g. Baldwin and Von Hippel, 2011; Sørensen, and Torfing, 2011). Dictionary definition for collaborative term refers to “involving two or more people working together for a special purpose” (Cambridge Advanced Learner's Dictionary & Thesaurus, collaborative entry) or “to work jointly with others or together especially in an intellectual endeavour (Merriam-Webster.com Dictionary, collaborative entry) or a piece of work produced by two or more people or groups working together (Oxford Advanced Learner's Dictionary, collaborative entry). The collaborative innovation concept belongs to the family of open

innovation concepts, a term coined by Chesbrough (2006) to emphasise collectively conducted research, development and innovation actions.

Over the years, in various disciplines, a great variety of collaborative innovation concepts and methodologies with varying names, conflicting and overlapping definitions have been presented. Therefore in this study we are not limiting the scope of the study to any specific research discipline. Instead, a cross disciplinary literature review and snowballing sampling approach is applied to look for terms describing various collaborative innovation and development activities among different types of groups of people while identifying and visualizing semantic relations between the terms. Secondly, the dominating collaborative innovation terms are identified by evaluating the popularity of the scanned terms based on the number of publications associated with the term.

2 Conceptual framework for identifying the terms

The Quadruple Helix innovation framework (Carayannis and Campbell, 2009) is taken as a starting point to search and classify the variety of collaborative innovation concepts and methodologies. Quadruple helix stakeholder groups consist academia, public sector, industry, and civil society. From each stakeholder group viewpoint, a scattered selection of concepts describing collaborative research, development and innovation activities can be identified. The author's prior knowledge on this thematic area was utilized to identify the initial set of terms for each quadruple helix group.

Among the research activity oriented academia stakeholder group, the concepts such as (1) collaborative research (Müller et al. 2013), (2) participatory research (Cornwall and Jewkes, 1995) and (3) citizen science (Eitzel et al. 2017) are well known approaches to describe collaborative research actions. However, even if the core research group and laymen form a partnership to mutually learn about the given research topic, the collaboration intensity between researchers and laymen can vary significantly cases by case.

In public sector, concepts such as (1) public or citizen participation (Rowe and Frewer, 2000), (2) public engagement or involvement (Rowe and Frewer, 2005) and (3) collaborative governance (Ansell, and Gash, 2008) are all consisting a group of procedures to consult and involve those who will be affected by the decisions and actions made by public authorities or politicians.

In industrial setting, collaborative business, product, service and technology development activities include e.g. (1) customer- and user-orientation approaches (Veryzer and Borja de Mozota, 2005), (2) co-creation (Sanders and Stappers, 2008) and (3) design thinking (Razzouk and Shute, 2012). All of these are emphasizing approaches to understand the customer needs by engaging customers in collaborative and collective development processes.

Civil society driven bottom-up approaches covers approaches such as community of practice (Wenger and Snyder, 2000) which is formed by groups of people who informally share expertise and knowledge relating something they are passionate about.

Although different kinds of meta-analysis and literature reviews have been made to clarify the scattered concepts, the prior studies are mainly focusing on a group of terms in a specific research domain (e.g. Ansell and Gash, 2008; Rowe and Frewer, 2005; Eitzel et al. 2017; Santonen, 2018). Therefore, a study incorporating multidisciplinary research literature is required to build linkages between different research domains.

3 Research design

The data triangulation (Denzin, 1978) approach was applied to increase the robustness of the collected bibliometric data. The data sources included Web of Science (WoS) as principal search system and Google Scholar (GS) as supplementary system (Gusenbauer and Haddaway, 2020). Using Google Scholar as a data source has been under discussion for many years and various benefits and weakness have been identified. However, when evaluating infancy and evolving research domains such as collaborative innovation, there is a need to look for the most up-to-date research also from low impact journals, conference proceedings, popular scientific literature, and other grey literature sources (Aguillo, 2011; Meho and Yang, 2007; Haddaway, et al. 2015).

At the first literature collection round, the search terms consisted a group of typical collaborative innovation, research and development concepts related to different quadruple helix stakeholder groups as described in section 2 (Arnkil et al. 2010). The aim of the first round data collection was to harvest the initial set of articles for the backward and forward snowballing procedure (e.g. Wohlin, 2014). The papers found in the first round were carefully read to identify the new overlapping and rivalling terms as well as identifying new publications based on reference lists. A series of read and search iterations were conducted before reaching the final list of 97 different collaborative innovation concepts and methodologies presented in research result section. After the rigorous data collection process, a framework approach proposed by Santonen and Conn (2015) was applied to evaluate the popularity of the identified terms. Popularity was measured by calculating number of papers having the search term in (1) publication title in WoS and GS databases and (2) topic fields in WoS and in anywhere in the publication in the case of GS.

4 Research results

4.1 Identification of the number of term variants and their popularity

A total of 97 different terms were identified based on the literature review. The terms and 67 individual words, which were used to form the terms, are presented in the Table 1. As a result, the following prefixes were utilized to form the terms: citizen (25 variants), collaborative (9), participatory (9), civic (7), co (7), community (7), user (7), public (6), customer (5), deliberative (2), living (2) and stakeholder (2). The following remaining nine terms had only one variant: Adaptive governance, Crowdsourcing, Design thinking, Discursive participation, Hackerspace, Makerspace, Political participation, Service design, and Testbed.

In the Table 1, for each prefix term group the number of publications results based on the title search is also presented for both WoS and GS databases. The top three ranking term groups based on number of publications for both WoS and GS were terms having “co”, “community” or “collaborative” prefixes.

Table 1 The different terms groups and their popularity based on WoS and GS title search results

<i>Prefix</i>	<i>Variants (N)</i>	<i>Term alternatives</i>	<i>WoS title</i>	<i>GS title</i>
Citizen	25	Activism; Based; Centric; Centric Design; Deliberation; Driven; Engagement; Evaluation; Involvement; Juries; Oriented; Panels; Participation; Participatory; Participatory Activity; Participatory Budgeting; Participatory Community Design; Participatory Design; Participatory Journalism; Participatory Noise Sensing; Participatory Processes; Participatory Transdisciplinary Research; Schools; Science; Sensing;	2 447	10 809
Collaborative	9	Design; Decision Making; Development; Governance; Innovation; Learning; Mapping; Modelling; Research;	3 625	31 192
Participatory	9	Action Research; Budgeting; Democracy; Governance; Innovation; Modelling; Procedure; Research; Sensing;	3 116	13 841
Civic	7	Based; Centric; Driven; Engagement; Involvement; Participation; Volunteerism;	1 326	6 222
Co-	7	Creation; Decision; Design; Development; Ideation; Operation; Production;	4 822	26 829
Community	7	Based Participatory Research; Concepts; Engagement; Involvement; of Practice; Participation; Volunteerism;	4 297	22 562
User	7	Based; Centric; Centric Design; Driven; Driven Design; Oriented; Oriented Design;	954	8 398
Public	6	Deliberation; Engagement; Hearing; Involvement; Participation; Sentiment;	2 602	15 052
Customer	5	Based; Centric; Driven; Oriented; Oriented Design;	477	3 705
Deliberative	2	Democracy; Public	455	2 091
Living	2	Lab; Laboratory	209	1 564
Stakeholder	2	Engagement; Participation	795	3 007
Adaptive	1	Governance	169	580
Crowdsourcing	1		2 215	10 200
Design	1	Thinking	594	6 380
Discursive	1	Participation	3	12
Hackerspace	1		5	42
Makerspace	1		84	724
Political	1	Participation	1 476	8 560
Service	1	Design	298	4 850
Testbed	1		956	10 400
<i>TOTAL</i>			<i>30 925</i>	<i>187 020</i>

In the Table 2, the top 20 terms based on WoS and GS title searches are presented. As result most of the terms in the both top 20 lists are the same excluding the following. GS database publications has more emphasis on design related studies, since terms design thinking, service design and collaborative design were included into top 20 list. WoS

databases results on the other hand highlighted more participatory action research, community based participatory research and public engagement terms. The most popular WoS terms were crowdsourcing, collaborative learning and political participation, while top three ranking GS terms were , collaborative learning, co-operation and testbed.

Table 2 The top 20 terms popularity ranking based on WoS and GS title search

<i>Top 20 WoS terms (title search)</i>	<i>N</i>	<i>Top 20 GS (title search)</i>	<i>N</i>
Crowdsourcing	2 215	Collaborative learning	14 900
Collaborative learning	1 491	Co-operation	10 400
Political participation	1 476	Testbed	10 400
Participatory research	1 468	Crowdsourcing	10 200
Citizen science	1 458	Political participation	8 560
Co-production	1 416	Public participation	8 060
Co-creation	1 360	Community participation	7 910
Community engagement	1 359	Community engagement	6 650
Public participation	1 056	Participatory research	6 470
Civic engagement	1 041	Design thinking	6 380
Community participation	1 018	Co-creation	6 230
Co-operation	989	Collaborative research	5 700
Testbed	956	Co-design	5 400
Collaborative research	932	Service design	4 850
Participatory action research	906	Citizen science	4 760
Co-design	855	Civic engagement	4 730
Community based participatory research	810	Collaborative design	4 120
Public engagement	791	Co-production	4 040
Community of practice	738	Citizen participation	3 730
Citizen participation	611	Community of practice	3 410

Table 3 Kendall rank correlation coefficients between WoS topics and title AND GS title topics and anywhere

	<i>WoS title</i>	<i>WoS topic</i>	<i>GS title</i>
WoS topic	0.893**		
GS title	0.873**	0.865**	
GS anywhere	0.792**	0.841**	0.815**

** Correlation is significant at the 0.01 level (2-tailed)

Kendall rank correlation coefficients presented in Table 3 were measured to evaluate correlation between the selected popularity measures (i.e. WoS title, WoS topic, GS title and GS all). As a result, strong correlations ranging between 0.792** to 0.893** were

identified between the all popularity variables. As a result, the both databases and the selected search fields, will give a very similar output considering the popularity ranking. Therefore, for the semantic connections analysis only one popularity value (WoS title) will be utilized for analysis purposes.

When investigating the terms more closely, the following words describing various types of actors were identified (see Table 5). When comparing Table 1 and 5 results, it appears that most of the terms including “actor” related word, are formed by using “actor” word as a prefix. Also, in most cases the terms are formed by using only one actor related word, excluding citizen panels, citizen juries and citizen participatory community design. Furthermore, the balance between terms including or not including actors related word are almost fifty-fifty (i.e. 49.3 percent of the publications are related with terms including actor word). Clearly the most popular “actor” terms are associated with community (N=4297) while the closest runner-ups are public (N=2624), citizen (N=2447) and crowd (N=2215).

Table 5 Key words describing the different types of actors doing the collaboration

<i>Terms</i>	<i>Dictionary definitions*</i>	<i>WoS title (N)</i>
Community	The people living in one particular area or people who are considered as a unit because of their common interests, social group, or nationality:	4 297
Public	Relating to or involving people in general, rather than being limited to a particular group of people	2 624
Citizen	A person who is a member of a particular country and who has rights because of being born there or because of being given rights, or a person who lives in a particular town or city	2 447
Crowd	A large group of people who have come together or a group of people with similar interests.	2 215
Civic	Of a town or city or the people who live in it	1 326
User	Someone who uses a product, machine, or service	954
Stakeholder	A person such as an employee, customer, or citizen who is involved with an organization, society, etc. and therefore has responsibilities towards it and an interest in its success	795
Customer	A person a person who buys goods or a service	477
Maker	A person, company, or machine that makes a particular thing.	84
Hacker	Someone who uses a computer to access information stored on another computer system without permission, or to spread a computer virus.	5
Panel	A small group of people chosen to give advice, make a decision, or publicly discuss their opinions as entertainment.	4
Jury	A group of people who have been chosen to listen to the facts in a court action and decide whether a person is guilty or not guilty or whether a claim has been proved.	3

*Based on Cambridge Advanced Learner's Dictionary & Thesaurus entries

4.2 Identification of the semantic connections between the terms

The semantic connections and colour classification between the identified terms are visualized in the Appendix Figure 1. In the figure, the nodes sizes are visualized based on degree centrality measure (i.e. counting how many connections each word has to other

words) to illustrate how many different terms variants each term has. The terms were also classified into groups by using colours coding. Grouping was done by using Gephi modularity algorithm, which is grounded on Louvain method (Blondel et al. 2008). The algorithm is grouping those nodes together, which are more densely connected together than to the rest of the network. The appendix Figure 2 is otherwise the same, but now the nodes sizes are visualized based the number of publication (WoS title) to illustrate, which terms in the semantic network are the most popular. As presented in Table 4, a total of eleven groups were identified and named based on the word having the highest degree centrality measure.

Table 4 Semantic groups ranked based on number of different words in the group

<i>Group name</i>	<i>Top 20 terms in the group (N)</i>	<i>Nodes (N)</i>	<i>Publications (N)</i>
Community	Political participation (1476), Community engagement (1359), Civic engagement (1041), Community participation (1018), Public engagement (791), Community of practice (738), Citizen participation (611)	30	9 216
Citizen	Participatory research (1468), Citizen science (1458), Participatory action research (906), Community based participatory research (810)	29	5 197
Co	Co-production (1416), Co-creation (1360), Co-operation (989), Co-design (855)	12	5 064
Collaborative	Collaborative learning (1491), Collaborative research (932)	15	3 731
Design	-	23	2 247
Crowdsourcing	Crowdsourcing (2215)	1	2 215
Public	Public participation (1056)	12	2 001
Testbed	Testbed (956)	1	956
Living	-	3	209
Makerspace	-	1	84
Hackerspace	-	-	5

The “community” group having 30 word nodes consisted the highest number of publications (N=9216) and included seven terms from the top 20 list. The second most popular “citizen” group includes 5197 publication and 29 nodes while having 4 terms in the top 20 list. The third “co” group had 12 word nodes, 5064 publications and 4 terms in the top 20 list. The remaining groups were collaborative (3731 publications, 15 nodes, 2 publications), design (2247, 23, -), crowdsourcing (2215, 1, 1), public (2001, 12, 1), testbed (956, 1, 1), living (209, 3, -), makerspace (84, 1, -) and hackerspace (5, 1, -).

5 Conclusions

The suggested study grounded on bibliometric and social network analysis methodologies is the first serious attempt to consolidate a large group of collaborative innovation and development concepts into single and easy to understand semantic network. The previous studies have mainly been focusing on describing the case studies, evaluating only one of the quadruple helix viewpoint or focusing on a specific research domain instead of applying multidisciplinary approach. This has led to a collection of scattered and research domain specific terminology.

The main contribution of this study is a visual terminology map for scholars and practitioners to discuss collaborative innovation and development activity terms beyond single discipline. The map includes a total of 97 different terms formed on the basis of 67 different words and the semantic connections between the words. The terms were clustered by using two different approaches (i.e. clustering based on the prefix word and clustering based on modularity analysis). In total, 21 different prefixed were detected while 12 out of these prefixes were related to actors. In all, the terms including or not including actors related words had somewhat equal number of publications. Therefore, preference suggestions to one side or the other cannot be made. When comparing actors related terms popularity, terms associated with community were clearly the most popular. Closest runner-ups were terms including public, citizen or crowd. Also civic related terms had relatively high popularity mainly due civic engagement term. Sensitivity analysis for the alternative grouping structure (i.e. grouping based on modularity) was made by altering resolution parameter in Gephi modularity analysis. As result, grouping structure is highly depending on the set parameters and therefore interpretation based on the group should be carefully.

In the further studies, the evolution of the terms popularity should evaluated in order to identify the rising and dying terms and possible underlying factors which can explain the usage of the terms among scholars. For example studies evaluating correlation between terms based on scientific disciplines and publication outlets would reveal, which scholars and disciplines are using the particular terminology. Moreover, detailed evaluation of the existing definitions is required to fully understand in-depth the possible differences between the terms. Anyhow, it is highly recommended for scholars to use the listed alternative terms, when doing a study on collaborative innovation and development. The popularity analysis results can help scholars to associate their studies and terminology with the dominant terms, which on the long run can help to achieve more coherent terminology to discuss collaborative innovation and development actions.

Acknowledgements

This study has received funding from the Academy of Finland under agreement No: [337843] for Tiedon huoltovarmuus kompleksisessa ympäristössä - Information Resilience in a Wicked Environment – project (IRWIN). For more information see www.irwinproject.fi/es/home. The author gratefully acknowledge this support.

References and Notes

- Ansell, C. and Gash, A., 2008. Collaborative governance in theory and practice. *Journal of public administration research and theory*, 18(4), pp.543-571.
- Arnkil, R., Järvensivu, A., Koski, P. and Piirainen, T., 2010. Exploring quadruple helix outlining user-oriented innovation models.
- Baldwin, C. and Von Hippel, E., 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization science*, 22(6), pp.1399-1417.
- Blondel, V.D., Guillaume, J.L., Lambiotte, R. and Lefebvre, E., 2008. Fast unfolding of communities in large networks. *Journal of statistical mechanics: theory and experiment*, 2008(10), p.P10008.
- Carayannis, E.G. and Campbell, D.F., 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International journal of technology management*, 46(3-4), pp.201-234.
- "Collaborate." *Cambridge Advanced Learner's Dictionary & Thesaurus (Online)*, Cambridge University Press. [Date accessed; 11.5.2021]. Available from <https://dictionary.cambridge.org/dictionary/english/collaborative>
- "Collaborate." *Merriam-Webster.com Dictionary*, Merriam-Webster, <https://www.merriam-webster.com/dictionary/collaborate>. Accessed 10 May. 2021.
- "Collaborate." *Oxford Advanced Learner's Dictionary (online)*, Oxford University Press. [Date accessed; 11.5.2021]. Available from https://www.oxfordlearnersdictionaries.com/definition/american_english/collaboration
- Chesbrough, H., 2006. Open innovation: a new paradigm for understanding industrial innovation. *Open innovation: Researching a new paradigm*, 400, pp.0-19.
- Cornwall, A. and Jewkes, R., 1995. What is participatory research?. *Social science & medicine*, 41(12), pp.1667-1676.
- Eitzel, M.V., Cappadonna, J.L., Santos-Lang, C., Duerr, R.E., Virapongse, A., West, S.E., Kyba, C., Bowser, A., Cooper, C.B., Sforzi, A. and Metcalfe, A.N., 2017. Citizen science terminology matters: Exploring key terms. *Citizen Science: Theory and Practice*, 2(1).
- Etzkowitz, H. and Zhou, C., 2017. *The triple helix: University–industry–government innovation and entrepreneurship*. Routledge.
- Gusenbauer, M. and Haddaway, N.R., 2020. Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research synthesis methods*, 11(2), pp.181-217.
- Haddaway, N.R., Collins, A.M., Coughlin, D. and Kirk, S., 2015. The role of Google Scholar in evidence reviews and its applicability to grey literature searching. *PloS one*, 10(9), p.e0138237.
- Müller, M.O., Groesser, S.N. and Ulli-Beer, S., 2013. How do we know who to include in collaborative research? Toward a method for the identification of experts. In *Dynamic Governance of Energy Technology Change* (pp. 83-104). Springer, Berlin, Heidelberg.
- Razzouk, R. and Shute, V., 2012. What is design thinking and why is it important?. *Review of educational research*, 82(3), pp.330-348.
- Rowe, G. and Frewer, L.J., 2000. Public participation methods: a framework for evaluation. *Science, technology, & human values*, 25(1), pp.3-29.
- Rowe, G. and Frewer, L.J., 2005. A typology of public engagement mechanisms. *Science, Technology, & Human Values*, 30(2), pp.251-290.

Sanders, E.B.N. and Stappers, P.J., 2008. Co-creation and the new landscapes of design. *Co-design*, 4(1), pp.5-18.

Santonen T., (2018). Comparing Living Lab(s) and its' competing terms popularity. , Proceedings of the ISPIM Innovation Conference (Stockholm): Innovation, the Name of the Game in Stockholm, Sweden on 17-20 June 2018., International Society for Professional Innovation Management.

Santonen, T., Normann, J. and Gertsen, F., 2016. Increased Variation or Higher Fences? Understanding Typological Evolution in Radical Innovation Management.

Sørensen, E. and Torfing, J., 2011. Enhancing collaborative innovation in the public sector. *Administration & Society*, 43(8), pp.842-868.

Veryzer, R.W. and Borja de Mozota, B., 2005. The impact of user-oriented design on new product development: An examination of fundamental relationships. *Journal of product innovation management*, 22(2), pp.128-143.

Wenger, E.C. and Snyder, W.M., 2000. Communities of practice: The organizational frontier. *Harvard business review*, 78(1), pp.139-146.

Wohlin, C., 2014, May. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In Proceedings of the 18th international conference on evaluation and assessment in software engineering (pp. 1-10).

Appendix:

Figure 1 The semantic connections between the terms (node size visualized based on degree centrality)

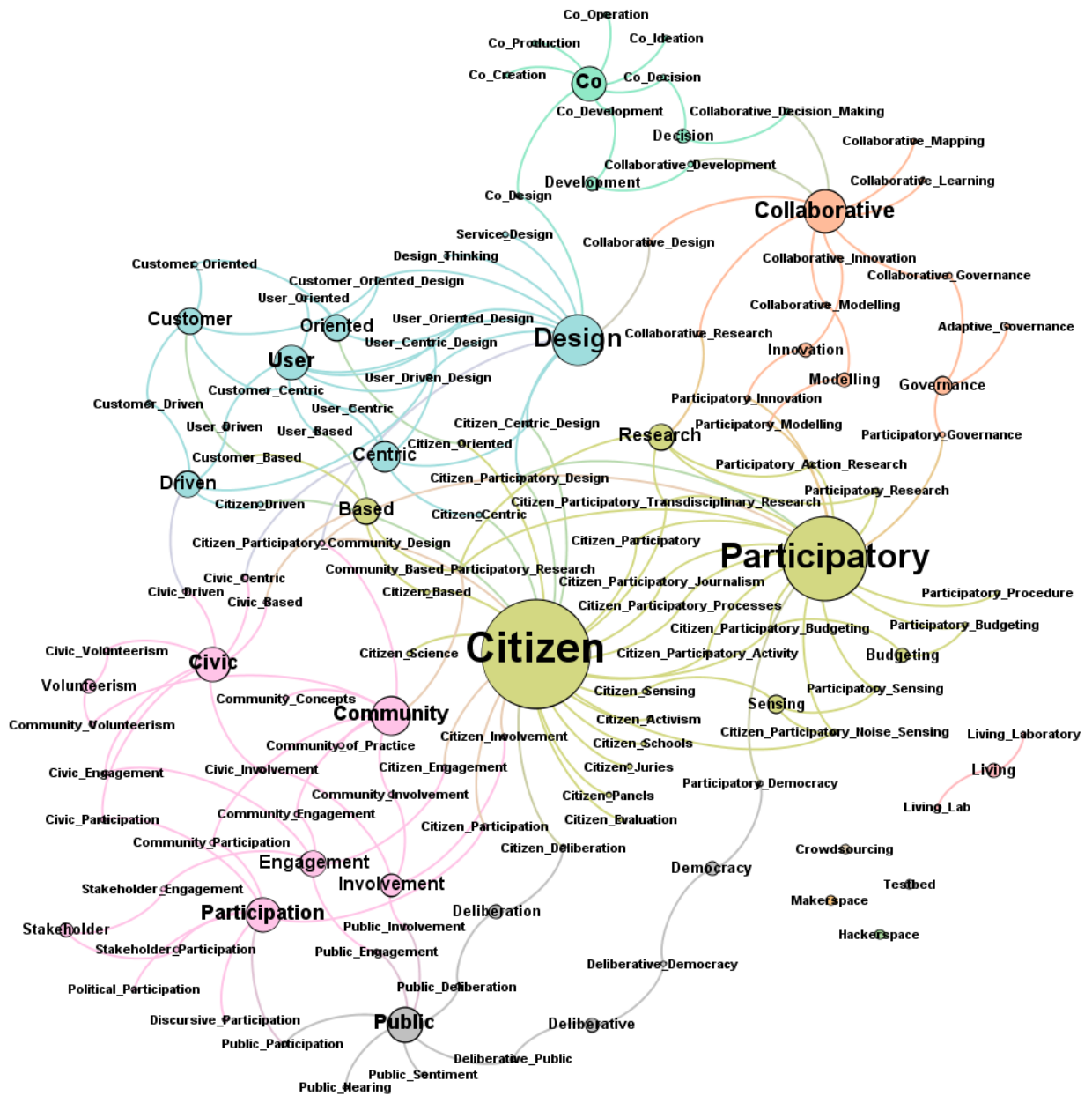


Figure 2 The semantic connections between the terms (node size visualized based on Web of science title search popularity)

