

Mapping and visualization: selected examples of international research networks

International
research
networks

381

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Abstract

Purpose – This paper aims to describe the popular trends and methods and ICT tools used for mapping and visualization of scientific domains as a research methodology which is attracting more and more interest from scientific information and science studies professionals. Science mapping or bibliometric mapping is a spatial representation of how disciplines, fields, specialties and individual documents or authors. The researchers analysed Bibexel, Pajek, VOSViewer, programmes used for processing and visualization of bibliographic and bibliometric data, within the framework of the implementation of IRNet research network project and activities and presented several examples of visualisation.

Design/methodology/approach – Among the main indicators of research effectiveness – bibliometric indicators – is a powerful information tool to support the development of science. Practical research methods were prepared using the programs: Bibexel (metadata analyses), program Pajek: graph editing and visualization of the graph structure of co-authorship – using the method of Kamada-Kawai and VOSviewer: a computer program for creating maps based on network data and for visualizing and exploring these maps. The main features of VOSviewer can be summarized for creating maps based on network data, visualizing and exploring maps.

Findings – The cited references and keywords are used to analyse in particular the intellectual base used by the research field or to analyse documents that cite the same references.

Originality/value – The authors of the paper, who are researchers of the European IRNet project and international research network, described and analysed certain bibliographic results of these activities using methods of mapping and visualization of scientific domains.

Keywords Networking, Mapping, Project, Visualization, Applications, Bibliographic and bibliometric data

Paper type Case study



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1. Introduction

The Digital Economy (DE) Theme is supporting research to rapidly realise the transformational impact of digital technologies on aspects of community life, cultural experiences, future society and the economy (www.epsrc.ac.uk/research/ourportfolio/themes/digitaleconomy/). DE brings together a unique community of researchers from diverse disciplines including social science, engineering, computer science, the arts and medical research and users including people, businesses and government, to study, understand and find solutions to real problems.

Modern science is also undergoing enormous changes and transformations. Science 2.0 is a term used to refer to processes, trends and phenomena related to the use of new technologies and information and communication technologies in science and, in particular, tools, services, publications and online resources. This trend stresses the benefits of increased collaboration and cooperation between researchers and scientists. However, it refers primarily to the consequences of using these technologies.

At this stage of Web 2.0 development, a popular trend has emerged whereby knowledge resources are mapped from public Web services. For example, a map of English Wikipedia articles was generated using a measurement registering common categories of articles (Holloway *et al.*, 2007). User activity specialist services also inspire analysis and mapping of data such as blogs and forums and users' logs (Bollen *et al.*, 2009). The concept of mapping and visualization of scientific domains as a research methodology described in particular in Cobo *et al.* (2011, 1383).

Scientometric and bibliometric approaches are being increasingly used by some authors to assess the evolution and structure of scientific knowledge and R&D output [Meyer, (2004); Wagner and Leydesdorff (2005); Dietz and Bozeman (2005); Adams, (2006); Hussler and Ronde (2007)]. Normally, studies within this research field [(Meyer, (2000); Meyer, (2004); Wagner and Leydesdorff (2005)] aim to appraise the scientific output of individuals, journals and even organizations (e.g. effective publication in internationally refereed journals and high citation scores) by surveying and analysing co-authorships and citation indexes.

In this study, we assume that an important component of the analysis of the subject area and the dynamics of the development of scientific knowledge is an analysis of discourse that reveals relationships, including hidden ones. Focus of the research: analysis of the effectiveness of network cooperation between researchers (through co-authorship of publications) and the degree of elaboration of the subject area (according to the keywords of publications).

The paper describes an example for the use of mapping and visualization tools for monitoring the results of joint research within the framework of an international project. The monitoring was carried out according to the TOTE model (Delaney, 2013) to increase the effectiveness of the joint network activities for the fulfilment of the project tasks. The evaluation of results included two groups of indicators, namely, network cooperation (publication activity and cooperation) and the degree of elaboration of the subject area (topics of publications).

2. Research context

2.1 IRNet project networking activities

The IRNet project aims to set up a thematic multidisciplinary joint exchange programme dedicated to research and development of new tools for advanced pedagogical science in the field of ICT instruments, distance learning and intercultural competencies in the EU (Poland, The Netherlands, Spain, Portugal and Slovakia) and non-European countries (Australia, Russia

and Ukraine). The project involved representatives of ten universities from countries with different degrees of competitiveness as a key factor for sustainable development of a country (Kommers *et al.*, 2015) and different Webometrics indexes (Smyrnova-Trybulska *et al.*, 2018).

Within the framework of the IRNet project (www.irnet.us.edu.pl), research is being conducted in several work packages (7 WPs) which are separate, yet simultaneously connected through interrelated stages, which roughly address our research focus.

The research is of interdisciplinary character and focusses on Humanities and Social Sciences and multidisciplinary aspects of science.

To accomplish the tasks of the project, the following network activities have been completed, producing the following results:

(1) Quantitative results:

- 205 monthly secondments were organised within the 4 years of the project;
- 47 researchers were involved in the exchange programme;
- 23 international conferences were organized;
- over 150 seminars and scientific workshops were held;
- 220 papers were published by members of the network, half of publications printed in high scored journals and/or indexed in Web of Science, Scopus and other international scientific bibliometric databases;
- research was conducted within seven work packages WP1-WP7 (over ten questionnaires, interviews, observations, literature analysis and statistical analysis);
- dissemination of results through a specially designed website www.irnet.us.edu.pl;
- over 100 multimedia albums were prepared; and over 10,000 photos were in the gallery at www.irnet.us.edu.pl/gallery.

(2) Qualitative results:

- International MA Programme “E-learning in Cultural Diversity” was developed and accredited;
- MOOCs “ICT-tools in e-learning” (<http://el.us.edu.pl/irnet>) was developed and started;
- *International Journal of Research* in e-learning was started (indexed in ERIH PLUS, Index Copernicus and ten other scientific databases); and
- A model of shaping ICT competences at the micro, meso and macro level was developed.

One of the tasks of the international research project was to conduct international research and publish the results in scientific journals. In this study, we evaluate the effectiveness of the project based on an analysis of the publication activity of its participants.

With that in mind, a bibliographic database was created containing all the articles and books from 2014 up till 2017 published by all IRNet researchers (178 publications, half in the scoring and indexing journals, monographs and proceedings) according to the following rubrics, namely, names and surnames of (co)authors, affiliation, title of publication, type (article, chapter, book, etc.), where published (conference proceedings, monograph, journal, etc.), year, keywords, indexing. This database also includes information on the number of authors, authors’ affiliation, country, year, research areas, keywords, the source of publication (e.g. journal and book) and certain other data. Consequently, this data set enables us to assess the main trends in IRNet scientific publications production.

The time frame of the analysis is the last 4 years of IRNet existence, in which we have been able to trace its knowledge production and dissemination. Based on the dynamics of

international co-authorships, we will be able to map and trace international collaboration patterns and thus infer IRNet geographical influence scope, i.e. its international influence.

By means of additional research using information available in the Institute for Scientific Information (ISI), namely, in the Science Citation Index (SCI), we assess the geographical pattern of the citations of IRNet scientific activities and production of publications. This enables us to evaluate to what extent IRNet project scientific production has been cited at the European and world level.

As the subject matter of the project is related to educational technologies or, to be more precise, to e-learning technologies, which is reflected in the participants' publications, one can assume that an analysis of international collaboration and the degree of participants' involvement in various countries, etc., will indirectly allow for an evaluation of the objectives of e-learning technology development in each partner country and institution.

2.2 Model of monitoring of performance of joint research

The research was conducted based on the TOTE (Delaney, 2013) model according to the proposed stages (Table I).

The use of the TOTE model allows for modelling the process of joint international research and flexibly correcting the activities, activities and (or) motivation of the participants. For example:

- In case of weak publication activity, the coordinator is invited to intensify scientific research and join other authors' groups, contributing to publications;
- In the absence of international co-authors, advise and recommend experts from this scientific area, primarily from the consortium; and
- In the case of repeated keywords, which indicates a weak development of the subject area, expand and deepen research, identify conference sections and update them regularly, taking into account, among other things and modern trends.

However, for the analysis and decision-making on the development or correction of network scientific interaction, it is necessary to present the results of the publication activity in a convenient form. We suggest using visualization and mapping tools, which will be described in the next chapter in more detail.

3. Science mapping

3.1 Analysing of tools, some aspects

Among the main indicators of research effectiveness, bibliometric indicators are a powerful information tool to support the development of science. Mapping and visualization of scientific domains as a research methodology is gaining more and more popularity among scientific information and science studies professionals.

The existing methods of information visualization have been successfully adapted in a network environment where websites, with some approximation, can be regarded as scientific articles and hyperlinks as quote links. This approach has promoted the rapid development of Webometrics (Zhao and Strotmann, 2008; Osińska, 2010).

According to Wagner and Leydesdorff (2005), authors within this research field are interested in the increase of the interconnectedness of scientists (Okubo, Miquel, Frigoletto and Dore, 1992; Luukkonen *et al.*, 1993; Zitt *et al.*, 2000; Gänzel, 2001; Cantner and Graf, 2006), in figuring out patterns of collaboration in general (Chung and Cox, 1990; Gibbons *et al.*, 1994; Katz and Martin, 1997; Dietz and Bozeman, 2005; Hussler and Ronde, 2007) and in international linkages in particular (Stichweh 1996, Schott, 1998) and further analysing

Nº	Title of the stage	Description	Example of implementation of IRNet project	Tools
1.	Test (T ₁)	<p><i>Identifying:</i> Goals and objectives of the project, criteria for achieving</p> <p>Creation of profiles of participants motivation</p>	<p><i>Objective of the project</i> The overall goal of this project was the study of innovative forms and effective methods of education, and above all, ICT techniques and e-learning methodology, evaluation of teaching competences and suggestion of effective strategies of implementing new innovative tools in the educational activity in the context of globalization of education</p> <p><i>The specific objectives of the project were</i> To explore indicators of educational effectiveness in the EU and third countries involved in the project To exchange experiences, analyse and evaluate teaching competences in usage of innovative forms of education and suggest effective strategies of implementing innovative ICT tools in the education activity To analyse and evaluate social, economic, legal and ethical conditions, as well as methodologies and models of e-learning techniques being developed in the European and third countries involved into the project To evaluate the effectiveness of the existing models/methodologies designed to provide e-learning and enhance intercultural awareness To develop a new model based on the current existing models/methodologies and literature review To evaluate and present new models/methodologies for an effective remote collaborative work and improve Information technologies in Education Science in EU and third countries To actively transfer knowledge with a view to generating strategic impacts in the thematic research area To promote scientific discussion about the integrity of systems of education and work focussing on competence issues in the context of globalization of higher education.</p> <p><i>Create a member profile</i> Subject area of the study (keywords) Number of publications The presence of profiles in scientometric databases h-index Criteria for achieving the objectives of the project (in the context of this article): Number of publications (effectiveness of the project's tasks) Co-authorship (effectiveness of joint activities) Keywords (the degree of development of the domain) Motivation: strengthening cooperation, exchange experience, scientific development, mobility, joint research, publication and conferences</p>	<p>Project site Profiles of participants in scientometric bases Social networks (including ResearchGate) Questionnaires and questionnaires</p>

(continued)

Table I.
Using the TOTE
model in the IRNet
project

Table I.

Nº	Title of the stage	Description	Example of implementation of IRNet project	Tools
2.	Operate (O)	Actions to achieve the goal	Conducting internships, conferences, discussions and online communications according to the project implementation plan	Project site (announcements and activity materials) Social networks (including ResearchGate) Conference websites Communities of practice PP for webinars Open journal system Scientometric bases
3.	Test (T ₂)	Comparison of the current state with the desired one	Periodic analysis of the achievement of the project objectives (according to the project implementation plan)	Mapping and visualization tools Profiles of participants in scientometric bases
4.	Exit	The point of choice is to finish or continue moving towards the goal	Comparison of the results of a certain stage. If T ₁ = T ₂ , exit from the process – go to the next stage, fixing the goal. Otherwise it is possible: to redefine the goal to change of operations to develop specification of the criteria for achievement to change motivation	Project website (reports) Profiles of participants Surveys and questionnaires

implications of linkages for funding and outcomes (Van Den Berghe *et al.*, 1998; Wagner *et al.*, 2000; Sequeira, Pacheco, Teixeira: p. 8-16).

To better understand the structure and dynamics of the development of individual science departments and to find a way to identify thematic trends, researchers analyse literature and the paths to cite individual publications. Analytical citation has been used in bibliometrics for a long time. The term developed by KDViz (Knowledge Domain Visualization) was coined by Ch Chena in 2001, editor of the leading information visualization magazine *Information Visualization* (common abbreviation: *Info Viz*). Because these methods lead to the generation of graphical maps, another name is used in parallel, that is, mapping science or, less often, scientography. This last one was introduced in 1960 by E. Garfield, founder of the Institute for Information Science in Philadelphia (ISI). Over the last 10 years, the domain knowledge visualization research has been extended to include information retrieval tasks (Osínska, 2010).

Science mapping or bibliometric mapping is a spatial representation of how disciplines, fields, specialties and individual documents or authors are related to one another (Small, 1999). It is focussed on monitoring a scientific field and delimiting research areas to determine its cognitive structure and its evolution (Noyons *et al.*, 1999). There are different important aspects to a science mapping analysis, such as:

- data sources;
- units of analysis;
- data pre-processing;
- similarity measures that can be used to normalize the relations between units of analysis;
- mapping steps;
- types of methods of analysis that can be used;
- some visualization techniques, and finally;
- interpretation of results.

Different approaches have been developed to extract networks using selected units of analysis (authors, documents, journals and terms). Co-word analysis (Callon *et al.*, 1983) uses the most important words or keywords of the documents to study the conceptual structure of a research field. Co-author analyses authors and their affiliations to study the social structure and collaboration networks (Gänzel, 2001; Peters and Van Raan, 1991).

Finally, the cited references are used to analyse the intellectual base used by the research field or to analyse documents that cite the same references. In this sense, bibliographic coupling (Kessler, 1963) analyses citing documents, whereas co-citation analysis (Small, 1973) studies cited documents. Other approaches such as author bibliographic coupling (Zhao and Strotmann, 2008), author co-citation (White and Griffith, 1981), journal bibliographic coupling (Gao and Guan, 2009; Small and Koenig, 1977) and journal co-citation (McCain, 1991) are examples of macro analysis using aggregated data (Cobo *et al.*, 2011: 1382).

Interesting research results were received by Spanish authors (Gomez *et al.*, 2016). According to their research, Spain was in 2013 the leading European country in MOOC course offerings and is at a leading position worldwide in the number of massive courses offered in 2014. This prolific activity is being transferred to the educational and scientific world in the form of posts in blogs, social networks and web pages, as well as scientific papers and books that attempt to analyse the movement from different methodological approaches. To date, there is no research that analyses the bibliometric impact of MOOC

movement in the Spanish scientific community. Therefore, the objective of this research is to perform a bibliometric study of the scientific impact in the form of scientific article or research book in journals and Spanish publishers from January 2010 to June 2014. The study was approached from a descriptive and quantitative methodology, taking as reference bibliometric indicators of production, number of citations and indicators of visibility according to their impact on different databases, namely, WoS/Social Science Citation Index, Scopus, In-Recs, Google Scholar and categorization of Spanish scientific journals (ANEP/FECYT). The results show that the impact of the Spanish scientific production in the form of books and scientific articles in prestigious international databases (WoS-SSCI/Scopus) is very low, although the national impact categorization according to ANEP/FECYT and In-Recs is moderately high (Gomez *et al.*, 2016).

Mapping and visualization on the timeline is comprehensively described and presented in Vieslava Osińska (2016, <https://monitorka12.wixsite.com/vowi/kopia-content-map>, access 22 March 2018).

Additionally, we conducted a comprehensive analysing of an international experience of researchers from different universities and from different countries, in particular: Garfield *et al.* (2003, December) concerning Mapping the Output of Topical Searches in the Web of Knowledge and the case of Watson-Crick; Review, Analysis, and Cooperative Study Among Tools for Science Mapping Software applications (Cobo *et al.*, 2011), Freeware for Scientometric and Bibliometric Studies (Mazov, 2012), Citation analysis in bibliometrics (Bredikhin *et al.*, 2013).

The following software products are used for processing bibliographic and bibliometric data:

- *Bibexcel* (2009): It is a software tool designed for many bibliometric uses by a Swedish scientist O. Perrson. Keywords (indicating what you can do with Bibexcel): bibliometric; bibliometry; citation analysis; co-citation; shared references bibliographic coupling cluster analysis; prepare bibliometric maps, mapping Pajek, NetDraw; Bibexcel uses ISI records, SCI, SSCI, A&HCI, but Bibexcel can also convert other formats (<http://www8.umu.se/inforsk/Bibexcel>, accessed 15 March 2018).
- *CiteSpace*, *CiteSpace II* (2004): An application created by Ch. Chen for various bibliometric analyses and visualization of results. It works with data formats downloaded from the Web of Science; database formats currently being developed include Scopus and Google Scholar (<http://cluster.cis.drexel.edu/~cchen/citespace/>, accessed 15 March 2018).
- *Sci2 tool* (2009): The Science of Science (Sci2) Tool is a modular toolset specifically designed for the study of science. It supports the temporal, geospatial, topical and network analysis and visualization of scholarly data sets at the micro (individual), meso (local) and macro (global) levels (<https://sci2.cns.iu.edu/user/index.php>, accessed 15 March 2018).
- *VOSviewer*: VOSviewer is a computer programme for creating maps based on network data and for visualizing and exploring these maps. The main features of VOSviewer can be summarized as follows: creating maps based on network data and visualizing and exploring maps; VOSviewer is written in the Java programming language, which means that it runs on most hardware and operating system platforms. VOSviewer can be obtained from www.vosviewer.com. The programme can be used freely for any purpose (www.vosviewer.com/, accessed 15 March 2018).

- *Pajek*: Slovenian free software, a programme valued by professionals for the analysis and visualization of large data networks (<http://viado.fmf.uni-lj.si/pub/networks/pajek/>, accessed 15 March 2018).
- *UCINET*: A programme available in a trial version for the design and analysis of social networks in the world of science; preferred data matrix (www.analytictech.com/ucinet6/ucinet.html, accessed 15 March 2018).
- *XLSTAT*: Commercial extension to MS Excel functions for statistical analysis and data visualization (www.xlstat.com/, accessed 15 March 2018).
- *Permap*: A free, small item of software for mapping methods of multidimensional scaling; especially recommended for application areas of psychometric and sociometry, which was developed at the University of Louisiana (www.ucs.louisiana.edu/~rbh8900/old%20web%20page.html, accessed 15 March 2018).
- *Vantagepoint*: Developed by Search Technology, Inc. in 2004 for visualisation and help in communication research results (www.thevantagepoint.com/, accessed 15 March 2018).
- *Network workbench tool (2007)*: The network workbench tool is a network analysis, modelling and visualization toolkit for physics, biomedical and social science research (<http://ivl.cns.iu.edu/km/pres/2009-borner-nico-nwb.pdf>, accessed 15 March 2018).
- *HistCite*: It is a large-scale computer tool for mapping science. Its power of visualization combines the production of historiographs on the basis of the analysis of co-citations of documents, with the use of specific bibliometric indicators. The main task of the package is to convert bibliographic data into a chronological diagram, with which you can obtain answers to the following questions:

Q1. How many works are published in a given scientific field?

Q2. Which countries, and when, made the most contribution to this area? In which languages were the works published?

Q3. Which magazines are the most “popular” in this field?

Q4. Which of them are the most important?

Q5. What are the most authoritative authors working in this area?

Q6. What publications are most important?

Q7. How different actors influence each other?

- *HistCite* is a software package used for bibliometric analysis and information visualization. It was developed by Eugene Garfield, the founder of the Institute for Scientific Information and the inventor of important information retrieval tools such as Current Contents and the Science Citation Index. (<https://en.wikipedia.org/wiki/Histcite>) (accessed 15 March 2017).
- *Publish or Perish*: It is a software programme that retrieves and analyses academic citations (www.harzing.com/resources/publish-or-perish, accessed 15 March 2018).

3.2 Network analysis: presentation of the results

We propose to consider an example of using mapping and visualization tools (Table II) to monitor project performance (Table I).

For the study of science as a process of scientific communication, which is relevant to this study, one can use the tools of network analysis. As a tool for analysis and visualization of large-scale networks, we can recommend Pajek (Pajek, 1996). However, for complex types of analysis, one must have competencies helping one to work with specialized products and to develop programming skills.

To carry out a network analysis of participants of the project, we will build a network of co-authorship for research activity and presentation of results in scientific publications.

Analyses of data for the purpose of network analysis were performed using Bibexel, starting with obtaining initial data for this programme. These data (up to the end of 2016) were assembled using built-in tools of the scientometric database Web of Science. Data for each participant in the project IRNet are files with the extension .txt which were combined using the programme Bibexel: in the new window "Type new/file name here", one should enter name which needs to have the merged file, select all the files one wants to merge and run Files -> Append all selected files to another.

For building a graphics editing programme Pajek (<http://mrvar.fdv.unilj.si/pajek/>) the following objects were used:

- 1. Networks are the main objects (vertices and lines), and the default extension is: .net. In this case, the created file is Analiz.net of the 83 vertices – authors' articles and links between them, reflecting the co-authorship in publications. The file specifies an additional property of vertices – the identity of the authors who analysed the participants of the project (diamond). The names of the authors of publications who are not participants in the project are indicated by triangles.

*Vertices 83

- 1. 1 "K. P." diamond
- 2. 2 "S.T.E." diamond
- 3. 3 "M.N." diamond
- 4. 4 "N. T." diamond
- 5. 5 "P. T." diamond
- 6. 6 "Y. O." diamond
- 7. 7 "S. I." diamond
- 8. 8 "Z. V." diamond
- 9. 9 "Y. K." diamond
- 10. 10 "Y. K." Triangle

...

*Edges

- 1 2 10
- 1 3 8

- 2. Vectors – file Analiz.vec, contains 83 entries, where for each vertex (author) its quantitative characteristic (real number) – the number of publications is indicated.

*Vertices 83

- 1 12 2 58 3 53 4 27 5 30

- 3. Partitions – file Analiz.clu, where for each vertex the class is defined to which it belongs. In this case, there are 10 classes, in line with the countries' mission project participants:

1- Australia, 2- Czech Republic, 3 – Netherlands, 4 – Poland, 5- Portugal, 6 – Russia, 7- Slovakia, 8- Spain, 9 –Turkey, 10 – Ukraine.

*Vertices 83

- 3 4 10 6 6 6

As a result of the visualization of the graph structure of co-authorship, we have obtained a Kamada-Kawai layout (Tomihisa Kamada and Satoru Kawai) (Figure 1).

However, it should be noted that visualization network analyses are often unreadable because they contain a large number of nodes with one or two connections.

The concentration of connections allows for visually accentuating the centres of the analysed activity, but it complicates general perception and makes the label unreadable. To view maps based on the results of the network analysis, it is recommended that the concentration of connections be reduced. Therefore, by means of the programme Pajek a subnet was created consisting only of participants of the project (Operations/Network + Partition/Extract SubNetwork). When one starts this, first it is necessary to create a file - Part.cls where the elements of the desired cluster should be grouped. In this case, it is 42

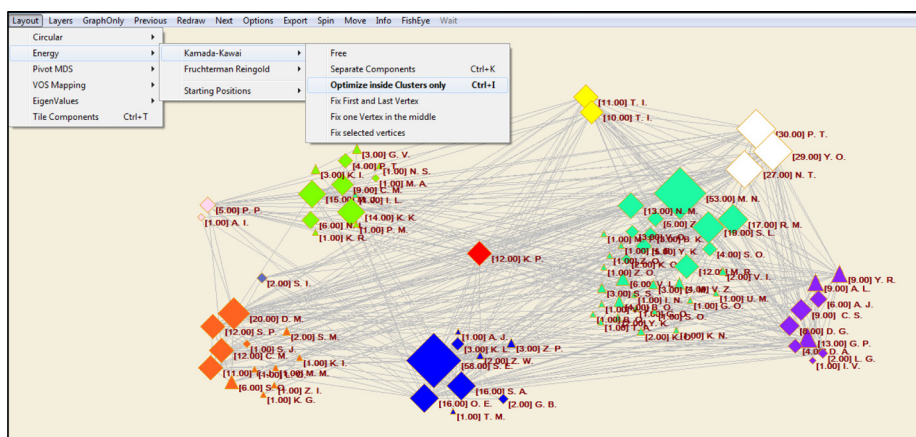
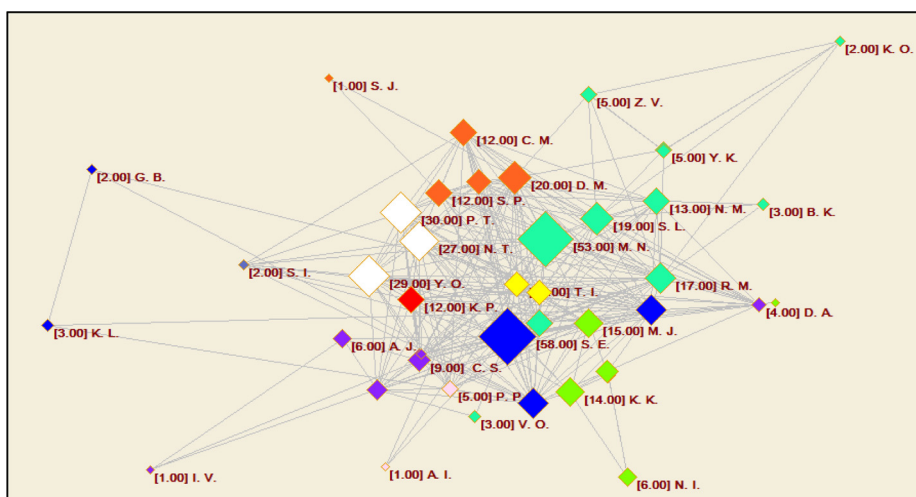


Figure 1.
Example of
visualization of co-
authorship with the
countries' mission of
project participants –
Kamada-Kawai
Layout

Figure 2.
Example – the
visualizing of the
graph structure of
co-authorship of the
project participants –
Kamada-Kawai
layout



- *Communication with the REA*: informing about the project progress and necessary modifications.
- administering the project website, completing with new content.

The overall responsibility for the management of the project rested with the project coordinator, Eugenia Smyrnova-Trybulska, from the USA. She was assisted by a Management Support Team from the coordinating institution and supported by the competent administrative assistant. The leaders of the teams constituted a Project Management Board and took the most important decisions concerning the implementation of the project.

In February 2014, the website of the project was running at address www.irnet.us.edu.pl including the most important information about IRNet project. The website with a branched structure, personification and interactive services such as forum was created by the Coordinator (USA). The website was regularly updated with new content and constituted an access point for all project documentation, meeting minutes and contains a photo gallery providing the participants with the opportunity to demonstrate their secondments and research activities. It also has a forum and a secure area for circulation of papers, etc., between project participants. The logo of the network was designed by a graphic designer.

Additionally, an IRNet profile on Facebook has been started at www.facebook.com/IRNet-1669593856645370/ and IRNet profile on Twitter is https://twitter.com/irnet_project.

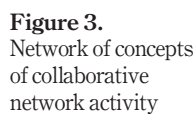
Management of secondments was successfully conducted by each partner and beneficiary providing administrative support to seconded researchers, that is, help with the invitation procedure, visas, accommodation, organising office space and working facilities, as well as knowledge exchange and research training activities, inviting the visitors home and to social activities and ensuring that they feel welcomed and integrated into the hosting university.

To determine the scientific impact of the project, participants in the development of pedagogical science an additional analysis needs to be conducted. The latter refers to the second group of indicators evaluating the effectiveness of the project. For monitoring purposes (Stage T₂), a keyword analysis was conducted, also to identify the most “top” topics, related to the subject of the project. For the analysis, articles were used of the project participants—representatives of various countries with the greatest publication activity (Figure 2) placed in the Web of Science. These include S.T.E. (Poland), M.N. (Ukraine), N.T. (Russia), D. M. (Slovakia), M. J. (Czech Republic), T. I. (Australia), G.E. P. (Spain) and K. P. (The Netherlands). The limitation of the articles is the project years (2015-2017).

As a tool for analysis and visualization, the VOSviewer package, specially designed for analysing bibliographic data, was used (Polley, 2015). Using the method of data normalization by the degree of association allowed for obtaining a map of the conceptual field of project participants’ joint network activity (Figure 3).

As follows from the analysis of the conceptual field, 250 concepts are presented on it (out of 1,755 selected keywords), united into 7 main clusters:

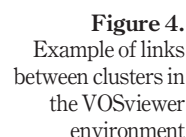
- (1) *Red cluster*: Concepts related to e-learning, change and IRNet project;
- (2) *Green cluster*: Groups of the concepts of condition and learning activity;
- (3) *Purple cluster*: Knowledge and challenge;
- (4) *Pink cluster*: Person and quality;
- (5) *Yellow cluster*: Communication and perspective; and
- (6) *Orange cluster*: Implementation.



The analysis of clusters and links (Figure 4) allows for drawing a conclusion about the degree of development of the project's subject area, as well as for making changes. For example, when planning a conference, an additional, very specific topic could be included, a clearer and more complete description of the subject matter of the issues under consideration could be provided, on one hand, to take account of new trends and, on the other hand, to strengthen the "weak" direction. Or such topics should be suggested that take into account the participants' experience and scientific interests and thus contribute to closer collaboration. For example, the annual international scientific conference:

E-learning Methodology – Implementation and Evaluation (2016), Effective Development of Teachers' Skills in the Area of ICT and E-learning (2017), E-learning and Smart Learning Environment for the Preparing of New Generation Specialists (2018) which take into account modern global trends on one hand and important direction for successfully implementation of the project on the other hand.

A complete collection of literary sources to study the field of joint publications in the framework of the project was carried out with the help of the bibliographic manager Zotero (Puckett, 2011). The collected data can be exported to RIS-format, which allows for their further analysis and visualization.



4. Discussion

From the point of view of network analysis, it is important that people should not be simply related to objects and rules in a network of relationships, but also that they should be able to occupy different positions in this network. This situation may change as the network (project) develops. There are participants who are linked with a large number of objects and different activity, they create new concepts, methods of using tools and determine the rules for measuring the effectiveness of their use. There are participants who are just beginning their activities in this community, and they are associated only with a small number of objects (for example, private practices or partnerships within the university). Stage by stage, a person can master an increasing number of objects and tools and move towards such a position in the community when he/she himself/herself will determine the rules for creating and using tools and techniques within the community.

The application of the proposed model to monitor project performance and simulate the network interaction of its participants showed positive results. Correction was carried out every six months.

According to the results of an online survey of project participants, 82.4 per cent (Figure 5) of respondents believe that the project network will contribute to the project development and dissemination of its results.

5. Conclusion

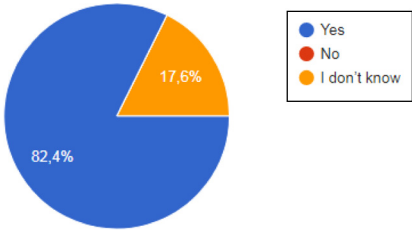
This publication is devoted to one of the popular trends referred to as mapping of scientific domains and visualization of research results in international networks. It can be considered as a research methodology which is gaining more and more popularity among scientific information professionals and specialists from different disciplines.

There is an extensive offering of various types of software for processing of bibliometric data – open source licence and commercial licence programmes.

One may state that the knowledge generated by the project and partnership’s important contribution to the area of European and international research includes the following:

- A data set for the analysis of the ICT, e-learning, intercultural competences developing effect in different EU countries; the results were published in series of scientific articles, in particular in prestigious indexed journal *IJCEELL*.
- Literature and IT tools were reviewed and the place and level in European educational system and in the project partners countries were analysed. The arrangements of different types of temporary work contracts as implemented in each of the EU countries under consideration were studied.
- A detailed ICT and intercultural competences developing methodology for the evaluation of the network research effect in educational institutions of different EU countries was designed.
- Enhancement of the classification of different welfare state regimes and assessing their effectiveness to represent different educational institutions were conducted. This result was achieved also by means of a cluster analysis of the systems based on different methodologies and variables.
- Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). It is the main task of exploratory data mining, and a common technique for statistical data analysis, used in many fields (survey, questionnaires, research, analysing using maths stat tools and publications).
- A detailed identikit of the teacher in each of the six EU countries and three non-EU project countries as expression of a given educational regime.
- Country studies aimed at assessing the network research effect in each country were conducted. The important stage of elaboration of these studies consisted of submitting them to international journals; implementation of methodologies

Figure 5.
Distribution of
responses concerning
project network
contribution to the
project development
and dissemination of
its results



Source: Own research

(innovative MA course, postgraduate study, training courses, MOOCs, publications, project journal *IJREL*, ICT tools, more than 20 didactic videos, etc.).

- A cross-country study of the network research effect.

The authors of the article, who are researchers of the European IRNet project and international research network, described and analysed certain bibliographic results of these activities using methods of mapping and visualization of scientific domains.

The experience of the use of visualization to monitor project-related publication activity, based on special software, has shown its effectiveness in relation to coordination and correction of work and favourable effect on the quality of the project results.

The methods for visual representation of scientometric information can serve as a basis for formulating preliminary working hypotheses in scientometric data analyses and for presenting the final results of analyses, in this case being a statistical analysis (a scholar's profile), a geospatial analysis (of member states) and a network analysis (participation in the project). Scientometric information mapping is closely related to the task of preparing forecasts of science development and improving the quality of existing forms of collaboration and developing new ones. The results obtained give grounds for supposing that the development of science branches and disciplines depends, to a large extent, on the existence and development of human capital and collaboration forms (we examined collaboration on this project only, but collaboration as such is limited to that) and, to a lesser extent, on identifying prospective fields of study and areas of technology. Further research will be pursued, among other things, to design a thematic-based collaboration model (constructing scientific e-communication models) and to assess the effect on scientists (and individual scientists) and science in general.

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