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Scientometric Analysis of the Researches About Technological Pedagogical Content Knowledge and Scholarly Communication

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Abstract

The technological integration issue in education is examined in educational researches with its different aspects and especially in recent years, comes into a more important position all over the world. Technological Pedagogical Content Knowledge (TPACK) studies, which we confront frequently in this context, increase scientific accumulation of knowledge for using technology effectively in teaching different subject areas and provide teacher training a new dimension. In addition to the researches that contribute to form theoretic framework, application oriented studies also attract the attention. This study aims to reveal the scholarly communication of the researchers, to specify the documents and authors efficient in the field and to reveal extensive conclusions in the context of document and author by examining the researches that are conducted about TPACK. In this sense, it is thought that this study will reveal the current situation on this subject and contribute to the planning of future researches. The study is conducted with 543 documents in total which are books, reviews and researches about TPACK that are acquired from Web of Science (WoS) and Scopus databases. By using bibliometrical method, the scholarly communication pattern in TPACK area is tackled in the context of author and document and the prominent authors and documents on yearly basis and is presented with scientific mapping method by visualizing. Thus, extensive conclusions are revealed about the documents about this subject and the authors of these documents.

Keywords

TPACK
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Introduction

Nowadays, it is seen that the information we require is in a continually ageing, changing and updating cycle (Niess, 2005). Technology reflects its transformative effect from social, cultural and political aspects to the individuals and accordingly to the community with applications that make daily life easier. The usage of technology in several environments with its different aspects is helpful in the areas of its usage in our daily lives and also helpful in the areas to develop education oriented content and extend pedagogical applications. The usage of technological infrastructure which has the accessible and generalized perception by the educators in educational processes makes it convenient to reach the targeted educational outputs effectively (Angeli & Valanides, 2009).

Tool usage in educational processes has undergone a change and development from the usage of chalk and blackboard to the usage of the current technology (computer and mobile technologies). Widespread technological tools like chalk, blackboard and projections have been started to be perceived as essential tools in the studies that are aimed at educational technologies and go out of the innovation perception (Reiser, 2001). Besides these tools, by computers taking place effectively in primary and secondary schools since the early 1980s, lots of studies are carried out about the participation of technology to the educational processes. Most of these studies are carried out about the usage of technology the talent, knowledge, tendency and beliefs of teachers to use the technology in educational processes (Brantley- Dias & Ertmer, 2013). But the usage of computer technologies with the aim of enriching the content about pedagogy and branch field knowledge in teaching methods is tackled in different manners. In the studies that are carried out, by general expression technological tool and equipment usage, the models that are especially aimed at using computer in educational processes, junction point of the technology and education are the subject areas that are examined with priority (Valanides & Angeli, 2006).

With the proliferation of the internet, technological knowledge started to gain a critical importance in educational literature. In the early period, Pierson (2001) carried out an extensive research about the difference of approaches towards the technology usage in classes. While the studies that are aimed at this struggle which are called content knowledge and pedagogic studies are examined as separate research areas, the first theoretical unifying study was carried out by Shulman (1987). Shulman tackled these two areas in an integrative context that sees them as consistently interactive. Mishra and Koehler (2006) added the technology dimension to the theory that is developed by Shulman about pedagogic content knowledge (PCK) structure. In this situation, a new structure in which technology, pedagogy and content knowledge are tackled together in both application and theory has emerged as a new structure. In other words, with these three dimensions which are examined in a unifying theoretical framework the area is extended to become TPACK (Jang & Chen, 2010).

TPACK framework contains a multi-dimensional structure that has totally 4 intersections which contains the intersection of technology, pedagogy and content knowledge notions and besides the intersections of these three. To make this structure understandable, application areas and sample applications are having been implemented (Koehler & Mishra, 2009). Although, Mishra and Koehler (2006) mentioned a theoretical unifying framework in the technology, content knowledge and pedagogic study areas, there are studies which tackle the relationship of these three areas with each other (Niess, 2005; Pierson, 2001; Slough & Connell, 2006; Wallace, 2004; Zhao & Frank, 2003). But the differentiating point of the study of Mishra and Koehler from the previous studies is that they explained TPACK notion in theory rather than sample applications.

TPACK researches swiftly adapt the developments in information and communication technologies. While the studies about the field increase cumulatively in accordance with the years, it is seen that different studies are carried out to specify the subjects that are tackled and the research focuses (Figure.1). Besides the examination studies (Abbitt, 2011; Chai, Koh, & Tsai, 2013; Niess, 2011; Rosenberg & Koehler, 2015; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013), there are studies carried out by the content analysis method which reveal the overall picture about the research kind in

the field (Kelly, 2010; Koh & Divaharan, 2011; Yilmaz, 2015) and also by the scientometric analysis methods (Wu, 2013).

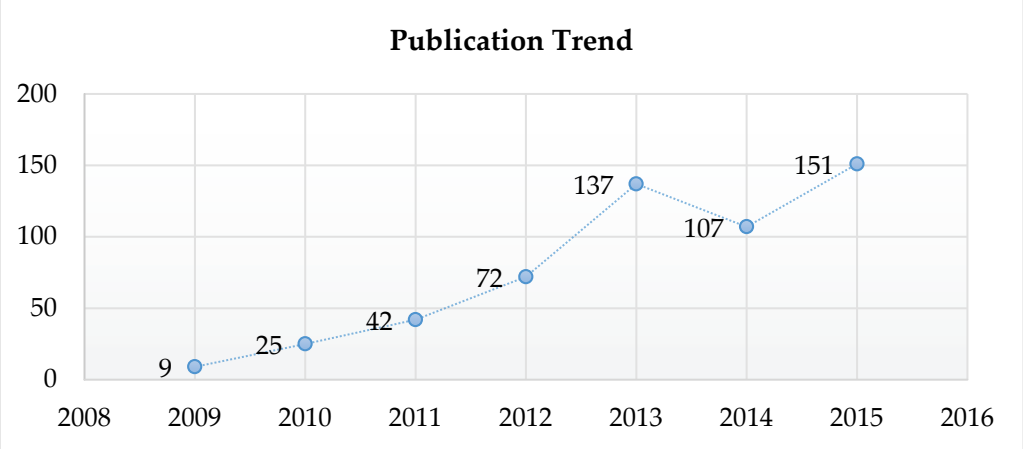

Figure 1. Number of Publications about TPACK Based on the Years

With the augmentation of the studies about TPACK notion and the interest about the issue, to make it convenient to use, the notion TPCK (Technological Pedagogical Content Knowledge) has been switched to TPACK (Technological Pedagogical and Content Knowledge) by Thompson and Mishra (2007). Thus, both pronunciation convenience and a mutual notion unity that is aimed at keyword search strategies in the academic databases is provided (Koehler & Mishra, 2009). After the descriptive keyword changed, TPCK and TPACK have been continued to be used together. But, as it can be seen in Figure 1, the publications trend, a quantitative document augmentation aimed at increasing the interest about the subject is not observed.

The theoratical framework similar to the description of TPACK by Mishra and Koehler (2006) is conducted by different researchers with similar aspects about the subjects they contained (Angeli & Valanides, 2009; Jimoyiannis, 2010; Lee & Tsai, 2010; Yeh, Lin, Hsu, Wu, & Hwang, 2015; Yurdakul et al., 2012).

Even though there have been lots of studies aimed at sample applications and different research questions about the field, in these studies neither the different sub dimensions of TPACK can be measured nor a simple and exact definition that teachers need are made. When we examine the literature, we see that there are still uncertainties' about determining the theoretical framework of TPACK area and that the discussions about the development of educational and content knowledge with the directive and intermediary effect of the technology still continue (Angeli & Valanides, 2009; Cox & Graham, 2009; Graham, 2011). The common ground that these discussions unify is that the structure is hard to understand from the aspects of content and application because the framework of the field is in the junction point of the three dynamic areas (Brantley-Dias & Ertmer, 2013; Graham, 2011). With this study that is carried out and in the studies aimed at the field, the general cognitive structure of the field is introduced depending on the prominent researchers and studies. One of the notions that are used to determine the cooperation webs which the researchers from similar study areas formed is social network analysis. With this phenomenon called invisible college; the structure of the research that is composed of the similar subject studies of the researchers from different geographical positions and institutions is revealed (Crane, 1972).

Scholarly Communication and Bibliometrics

Scientific communication contains a process in which researchers present their discoveries orally and in written form (Uçak and Al, 2009). In this process, each finalized process, in other words the processes that published, triggers the beginning process of another process. In this process, there are letters which contain the scientific criticism of a published result of a research and also citations about the publication in the other articles. Scholarly communication has been started to be implemented

as its present meaning with the publication of Philosophical Transactions and Journal des Sçavans Journals (Cronin, 2014), and although there have been lots of supplementary publication types it is possible to say that the most used publication type used with this aim is still the scientific journals. Scientific publishing which is affected by the information and communication technologies and the new publishing mediums that it brought together is meant to new communication mediums to emerge for scientific communication. The opportunities that these mediums provided meant for the researchers to communicate rapidly and have flexible study opportunities which annihilate the time and location restrictions and opportunities such as accessing the information in electronic media rapidly, up to dateness etc. is added to these opportunities, the dynamics of the scholarly communication has also started to change (Sompel, Payette, Erickson, Lagoze, & Warner, 2004). The authors, who are essential for the scholarly communication process, obtained much more information using electronic resources due to the extention of the scientific databases in electronic media. An increase at the number of bibliometrical studies started to be observed because of the increase in the usage of scientific databases. Bibliometrics is defined as a method which aims to gauge the scholarly communication that belongs to a specific discipline by applying the mathematical and statistical methods to the scholarly communication medias such as books, journals etc. (Pritchard, 1969).

Invisible College

Bibliometrics is shown among the methods which aim to reveal "invisible college" by describing the researcher communication networks (Ding, 2011; Zupic & Čater, 2015). Thus, it can be possible to describe the relationship of the researchers who do not study in the same institution but who support the same thesis in the aspect of academic ideas (Crane, 1969). According to Crane, the studies of the researchers who have a relationship socially show a relationship network that will provide publishing more than one document in the similar research areas. In other words, number of the studies and the similarities of citations in the studies form a common ground in the intellectual context. When this structure is examined according to the bibliometrical methods, while number of the researchers who published in an area intensely may change depending on the quantity of the area, also they are very little in number. This situation only provides to specify the researchers who are active quantitatively.

In specifying the notion of invisible college, the journals in which the scholarly communication is grouped and the articles which are the carrier of scientific data gain importance. Academic publications, especially articles are the scientific documents which are original in quantity and which aim to find answers to original research questions depending on very strict evaluation criterions (Lievrouw, 1989). This situation causes the academic publications, which are the products of scientific production, to contain two different knowledge as content and citation knowledge. In this regard, besides the content of academic texts, the resources which are used to make citations to base the opinions and ideas become crucial equally. In other words, to form the intellectual structure, the ideas of the people who became expert in the area at the time of scientific production are used to support the original ideas of the researchers (Anderson, 2006). In this context, it can be said that the intellectual communication is formed by the citations (Zuccala, 2006).

Taking into consideration the criticism about the theoretical structure of the field, to reveal scientific accumulation about the field and scholarly communication structure with an objective method based on data is crucial to define the overall picture of the development of the field from past to the present time. Based on this importance, an objective approach is needed to examine the prominent authors and studies by a structure except an objective evaluation systematic based on expertness and to reveal the general situation in the area. Invisible college notion is the one that bibliometrical studies use frequently to express the theoretical basis of this approach. This notion is considered as the essential approach which is used in the studies to specify the scholarly communication and the most effective studies in the field and the researchers who are the intellectual leaders about revealing the invisible colleges in the area.

This study aims to reveal the scholarly communication of the researchers, to specify the publications and authors efficient in the field and to reveal interactions in the context of publication and author by discussing the scientific publications conducted about TPACK using bibliometric methods.

Method

Data Compilation Strategy

In the study, Web of Science (WoS) and Scopus databases have been used to compile the data which will be used in citation analysis. Both of these databases provide the chance to access the citation statistics of scientific publications which are aimed at general and to access the bibliographical data of the publications (Meho &Yang, 2007). By the force of citation analysis method, the citation information in the data set must be consistent and valid in the aspect of science, and this forms the precondition of the analysis (Shibata, Kajikawa, Takeda & Matsushima, 2009). When these points are taken into account, although Google Academic database provides access to more documents, it is excluded because of the consistency and reliability criterions (Mikki, 2009). Even though ERIC is an education-themed database, it is seen that ERIC does not present the analysis conditions because it does not have a structure that contains the citation statistics and therefore is excluded (Corby, 2009). In the research, WoS database is preferred because it increases quality condition since it indexes the journals which have relatively high impact factor (Bar-Ilan, Levene & Lin, 2007; Jacso, 2005), Scopus database represents general comprehensiveness since it indexes more academic publications in number (Ball & Tunger, 2006). With the help of the data compiled from WoS and Scopus, it is aimed to reach the broadest access in terms of extensiveness and scientific quality standards.

Data Compilation Criterions

For the data compilation criterion, Lexical Search Strategy approach is used (Mogoutov & Kahane, 2007). Lexical search strategy provides the compilation of the documents which are extended and indexed in different thematic research areas with the help of database tomography approach and with characteristic word sets about the field that is examined inside the scientific databases and question clusters (Kostoff, 1994; Kostoff, Eberhart &Toothman, 1997). In the forming of the lexical search strategy, the data tomography strategies that have been used in the previous studies about examination and content analysis (Abbitt, 2011; Baran & Bilici, 2015; Chai et al., 2013; Yılmaz, 2015) are investigated, and the lexical search list which has the comprehensiveness proper to the aim of the research is formed (Figure 2 and Figure 3).

ALL("technological pedagogical content knowledge") AND **ALL**("TPACK") AND **PUBYEAR** > 2008 **AND** (**LIMIT-TO**(**DOCTYPE**,"ar") OR **LIMIT-TO**(**DOCTYPE**,"cp") OR **LIMIT-TO**(**DOCTYPE**,"re")) AND (**EXCLUDE**(**PUBYEAR**,2016))

Figure 2. Scopus Database Word Scanning Query (Database Lexical Search Query)

#1 AND #2
Refined by: **DOCUMENT TYPES**: (ARTICLE OR PROCEEDINGS PAPER OR REVIEW)
Indexes=SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH Timespan=2008-2015
#2
TS=("**TPACK**")
Indexes=SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH Timespan=2008-2015
#1
(TS=("**technological pedagogical content knowledge**"))
Indexes=SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH Timespan=2008-2015

Figure 3. Web of Science Lexical Search Query

While forming the periodical verge of the data set, the document year and the change in the field name (Thompson & Mishra, 2007) of the study forming the theoretical base of the study (Mishra & Koehler, 2006) is considered. In the online search queries, Scopus (Figure.2) and WoS (Figure.3) databases found 531 (Scopus) and 109 (WoS) documents by the question clauses. The acquired two different data sets have been combined and a reiterated record control is in the new dataset. Since WoS and Scopus databases include each other proportionately, it is seen that the same documents are indexed under the two different databases in both of the questioning results. To prevent the error effect that will be created by reiterated records, data set is cleaned and 543 single publications are specified. The final dataset consists of article, review and conference paper types of scientific publications.

Analysis Method

Bibliometrical methods have been among the methods that are used frequently to reveal the scientific ideology structure of the studies by examining their bibliographies with statistical methods (Ding, 2011). Scientific documents are seen as knowledge creatures that provide scholarly communication, in addition to their providing people to access the studies that researchers reveal their unique ideas (Borgman, 2000). Researchers form a communication network that will form formal or informal relationship patterns with the help of the scientific journals. These communication networks can both serve a planned target and can also show a structure that comes into existence by itself depending on the research subjects. At this point, it is possible to apply social network analysis methods rather by examining the scientific texts which express cognitive projections and which have a broader access opportunity than the researchers themselves (Crane, 1969; Lievrouw, 1989). Bibliometric analysis is based on scientific databases with a generally accepted confidence. For this reason confidence, validity and repeatability is provided as a beginning requirement (Colepicolo, 2015).

In researches about social sciences, grouping practices that are done depending on the statistical values provide the examined phenomenon to be separated from each other based on their different characteristics (Lievrouw, 1989). Content analysis method is considered prominent among the methods that are preferred to reveal the dynamics of scholarly communication (Abbitt, 2011; Chai et al., 2013; Niess, 2011; Rosenberg & Koehler, 2015; Voogt et al., 2013). The analysis of the content that has scientific quantity necessitates expertness about the field. In the evaluation of the expert, the most important risks that we come across are the risk that the evaluation can be made without the required attention and biasness risk when defining dataset (Zupic & Cater, 2015). Also the number of studies examined is also restricted depending on the time required for expert evaluation.

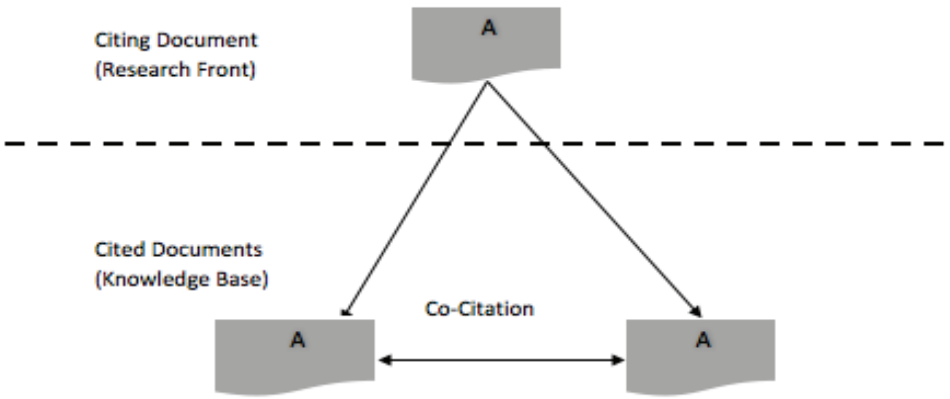

Figure 4. Co- Citation Analysis Structure

The visualization methods based on the bibliometric data aim to reveal patterns which are based on mathematical relation by making use of the meta data of the scientific studies (Boyack &Klavans, 2010; Klavans & Boyack, 2011). Meta data citation information is the most frequently used information

in the evaluation of the scientific relations. There are three different citation definitions such as bibliographical match (Kessler, 1963), direct citation and co-citation citation (Small, 1973) about the evaluation of citation knowledge. The co-citation among these citations was developed to investigate the connection between the documents which reference the same documents (Figure 4). The ideological structure which forms the field in the data set that is examined in the scientific map that is visualized by the analysis of this citation type allows the dynamics to be understood from the aspect of the relations and periodical changes (Rorissa & Yuan, 2012; Small 1999; Zuccala, 2006).

It is seen that the most preferred analysis methods are the "author co-citation" and "document co-citation" in the research models of the studies which examine the invisible college phenomenon according to bilimetrical methods (Di Stefano, Peteraf, & Verona, 2010; Nerur, Rasheed, & Natarajan, 2008; Rorissa & Yuan, 2012; Zupic & Čater, 2015). In the conducted study, evaluations about the field have been made by using these methods.

Author Co- Citation Analysis

Author Co-Citation Analysis is a bibliometrical-based method that found a broad application area in the different research areas (Gmür, 2003; Nerur et al., 2008). What serves as a basis of the method is the presentation of the examined bibliographical personal record transition frequency of authors who are conceptually effective and who caused to form the research focuses and the connection points which depend on the periodical changes in a network matrix (White & Griffith, 1981). The biggest flexibility that this method provides is that it can be applied to all of the research areas that have the adequate relation level and valid data set without needing an expert in the examined field (Anderson, 2006). In the studies that are carried out by the author co-citation analysis, it can be possible to ascertain the previous research subjects, paradigm changes, the productive authors in the area and the changes that refer to the rise of new research areas (Nerur et al., 2008). In the context of this study, the network pattern formed by the first authors of the publications which are used in the citations of the publications that are in the data set which includes the publications about TPACK is examined depending on years.

Document Co-Citation Analysis

Document Co-Citation Analysis differs from the Author Co-Citation Analysis in the aspect of the examined data and distribution of the data (Shibata et al., 2009). Document Co-Analysis is the analysis type which detects the most citated documents with the help of the bibliographical data in the examined data set (Chen, Song, Yuan & Zhang, 2008). The citation of a specific study by the studies in the bibliographical data shows that this study has a specific intellectual value as independent from the content in the data set. What is aimed with document co-citation analysis is to specify the emerging changes and forming of the new sub-research areas and development of these areas and to specify the areas that they are interacted (Chen, Ibekwe-SanJuan & Hou, 2010). In addition to revealing the area-oriented cognitive map depending on the citation numbers in the document co-citation analysis, the documents which make the changes that can form the milestone in the field are revealed depending on the statistical values (Ramos- Rodriguez & Ruiz- Navarro, 2004).

Data Analysis

In the research, with the aim of making the visual analysis of the authors and papers the contributed authors of the field benefited from their ideas in their intellectual communication process, "author co-citation analysis" and "document co-citation analysis" is made by using the CiteSpace program (Chen et al., 2010). Both of the two analyses are made based on the first most-citated 250 records for each year between 2009 and 2015. As a result of the analyses citation relations and relation patterns are visualized as cognitive maps. The grouping performance of the cognitive maps is evaluated depending on the modularity Silhoutte values. Along with the modularity value being between [-1, 1], the grouping performance's being higher than 0.7 in the absolute value in the knowledge visualization processes indicate a meaningful disintegration (Newman, 2004). Silhoutte value is the sum of cluster elements' degree of indifference levels (Kaufman & Rousseeuw, 2009). For the evaluation of the clusters, Silhouette value is used. While average Silhouette value gives the general interior dissociation rate of all of the clusters, the silhouette values in each of the clusters are used to specify the clusters which are

in meaningful size. The Silhouette value of the clusters being higher than 0,7 value is accepted as the indicator that the elements in the clusters are dissociated efficiently from each other (Rousseeuw, 1987; Simovici, 2007). When defining meaningful clusters, number of elements, modularity and silhouette values were chosen as evaluation indicators. In this research, clusters with at least ten elements in the cognitive map were taken into consideration.

When we consider the documents in the data set as continuous communication areas about TPACK area, detection of the authors and works that periodically draw attention of the researchers intensely is crucial to understand the periodical changes. Burst analysis is an algorithm that is developed to detect the activity density which emerges in specific periods between lasting documents (Kleinberg, 2003). With the help of the burst analysis, in addition to the detection of authors and documents which have high rates, the detection of the authors and papers who have periodical success can be used to specify the sub research areas that emerges in the field (Backstrom, Huttenlocher, Kleinberg & Lan, 2006).

Findings

Author Co-Citation Analysis

In the consequence of the author co-citation analysis that is made in the data set about indexed TPACK area, 12191 citation data analyzed from 543 documents. When the statistical value of the visualized knowledge is considered, the modularity happens to be 0.76 and the average Silhouette value happens to be 0.28. Silhouette value is the grand total of the indifference values of the elements that forms the cluster with each other. When these values are considered, it is seen that these are clustered efficiently from the aspect of data set clustering but from the aspect of indifference of the elements that form the cluster, an inefficient grouping has been done.

As a result of the clustering process that is done about the co-citated authors, 103 clusters have originated. When the separative relevance rates of the clusters is considered, a total of 20 relevant clusters have been obtained in which the silhouette value is higher than 0.7 and the number of cluster elements is higher than 10. In the naming method of the clusters, Log Likelihood Ratio (LLR) algorithm which is the method in which the words in the data set are gradated according to their frequency is used. While there are 77 elements in the "conceptualizing web" cluster which is biggest cluster, there are 14 elements in "process" cluster which has the smallest one (Figure 5). The most co-citated authors, according to author co-citation analysis results, are given in Table 1.

Table 1. The Most Co-Citated Author Table

Co-Citation Number	Co-Citated Author	Institution	Cluster
403	Mishra, Punya	Michigan State University	4
286	Koehler, Matthew J.	Michigan State University	4
267	Shulman, Lee S.	Stanford University	4
164	Niess, Margaret L.	Oregon State University	4
118	Archambault, Leanna M.	Arizona State University	4
116	Angeli, Charoula	University of Cyprus	13
105	Graham, Charles R.	Bringham Young University	4
104	Harris, Judi	Willliam & Mary School of Education	4
99	Ertmer, Peggy A.	Purdue University	2
98	Schmidt, Denise A.	Iowa State University	4

As seen in Table 1, among the most 10 co-citated authors in the field, Lee S. Shulman, Matthew J. Koehler and Punya Mishra who specify the theoretical framework of field take place in the first three. These three authors are followed by Charoula Angeli and Margaret L. Niess who contributed to the development of the field. It is seen that the cluster that citates to Charoula Angeli most is made by "Theoretical Consideration" cluster. The cluster which made the most citation to Peggy A. Ertmer is named as "informing one-to one computing". Except these two clusters, all of the most co-citated

authors take place in the "pre-service teacher" cluster. Burst analysis is used in order to find out authors that burst in some periods. The top ten authors in terms of activity power are given in Table 2.

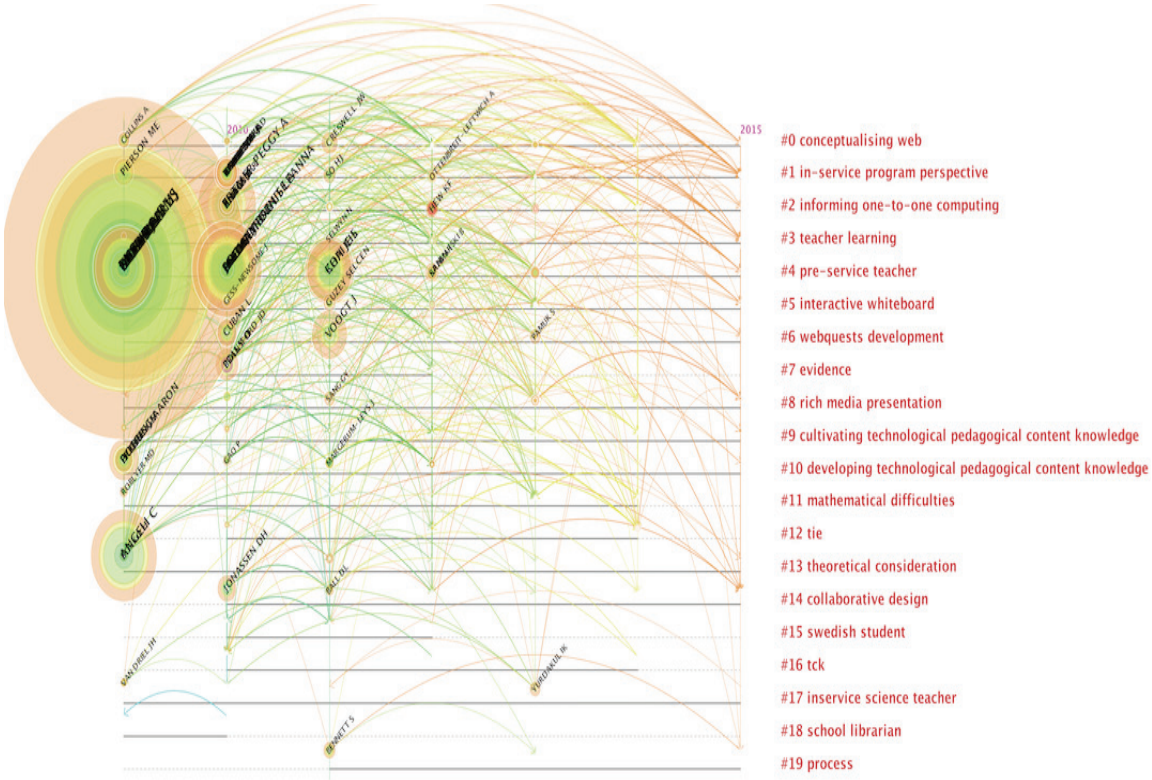

Figure 5. Author Co-Citation Scientific Map

To specify the authors who burst in the data set periodically, burst analysis is done. Since the data set includes only a seven-year period, burst analysis could have been done for a minimum of 1-year period. In Table 2, the specified names as a result of Burst Analysis and the institutions they work in take place. When the countries the institutions take place in are considered, the institutions in the United States are seen in the first place. China, Holland, England and South Korea are the other countries that follow.

Table 2. Authors Who Burst in the Author Co-Citations

Co-Citated Author	Institution	Activity Power	Beginning of Period	End of Period	Effectiveness
VAN DRIEL, Jan H.	Leiden University	2.6143	2009	2010	
THOMPSON, Ann D.	Iowa State University	2.8397	2010	2012	
GESS-NEWSOME, Julie	Oregon State University	2.1764	2010	2010	
SO, Hyo Jeong	EWHA Womans University	2.0817	2012	2012	
HARDY, Micheal	Saint Xavier University	2.1067	2012	2013	
RUTHVEN, Kenneth	Cambridge University	2.1067	2012	2013	
LAW, Nancy	Hong Kong University	2.2855	2013	2013	
HEW, Timothy Khee Foon	Hong Kong University	2.433	2014	2015	
WARSCHAUER, Mark	California University	2.667	2014	2015	
WHETTEN, David A.	Bringham Young University	2.3862	2014	2015	

There are not any same researchers between the authors that emerge in burst analysis results and the most co-citated authors. This situation shows that the authors who study continuously about the area do not have researches that intensely draw attention in the studies about the field in a specific period. When it is considered from this aspect, it shows that specific citations are made to the studies of the authors who are specified in the consequence of the burst analysis. It can be interpreted that all of the researchers in the Table 2 have conducted research in educational field.

Document Co-Citation Analysis

Different from the author co-citation analysis, document co-citation analysis includes the documents that take place in the references. According to the threshold value of the analysis, 9283 documents are included in the analysis. The modularity value of the cognitive map is specified as 0.82, silhouette value is specified as 0.34. The silhouette value of the document co-citation analysis is higher than the author co-citation analysis. In this aspect, it is possible to say that the homogeneity of the clusters is higher.

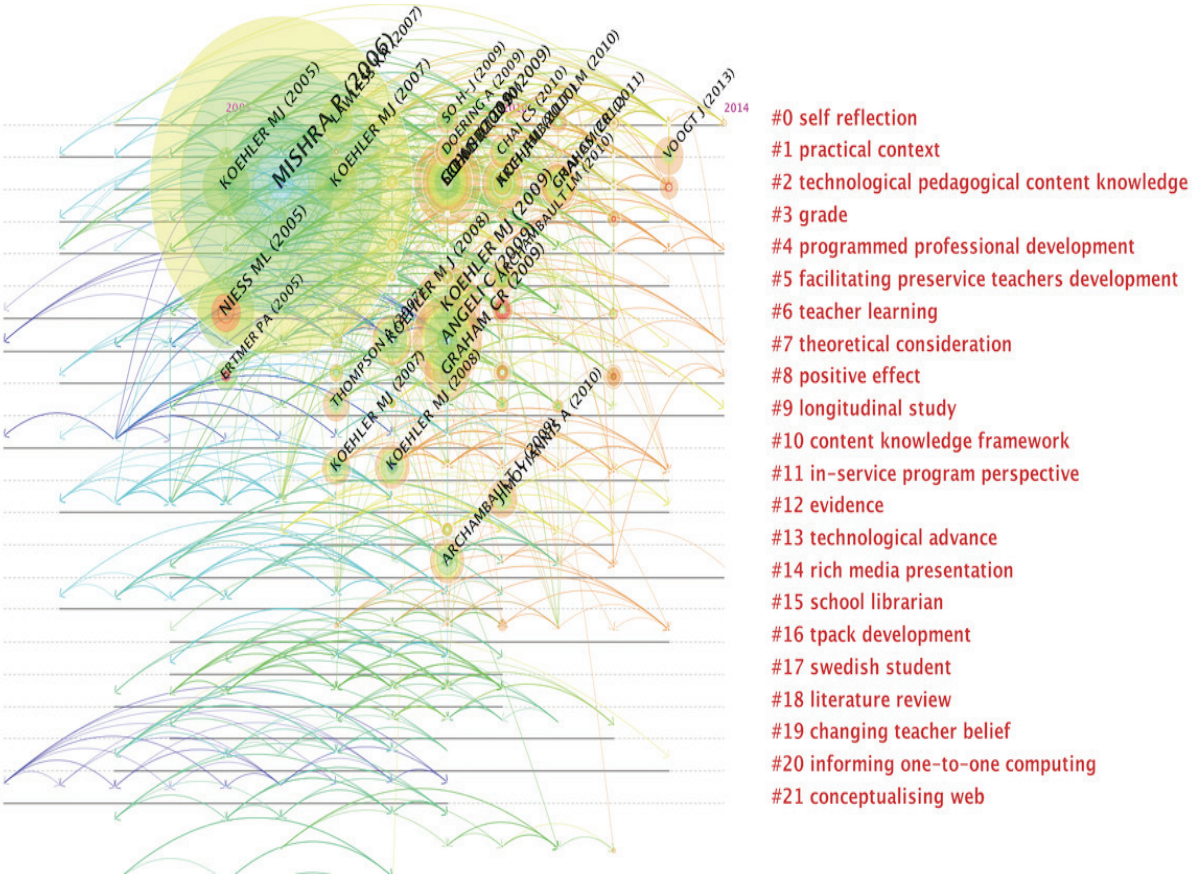

Figure 6. Document Co-Citation Scientific Map

In the consequence of the clustering process which is done according to the citated documents, 194 clusters are formed in total. Between the clusters there are 22 clusters that have a relevant size from the aspect of silhouette values. While the biggest cluster is "self-reflection" with 73 elements, the smallest cluster is "conceptualising web" with 12 elements (Figure 6). Table 3 represents the most citated ten publications according to the at least 50 co-cited threshold value.

Table 3. The Most Citated Publications (According to the at least 50 co-cited threshold value)

Citation number	First Author	Publication Year	Title	Journal Name
281	Mishra, P.	2006	Technological pedagogical content knowledge: A framework for teacher knowledge	Teachers College Record
77	Angeli, C.	2009	Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK)	Computers and Education
75	Koehler, M. J.	2009	What Is Technological Pedagogical Content Knowledge?	Contemporary Issues in Technology and Teacher Education
74	Cox,S.	2009	Diagramming TPACK in Practice: Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge	Tech Trends
65	Niess, M. L.	2005	Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge	Teaching and Teacher Education
57	Schmidt, D. A.	2009	Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers.	Journal of Research on Technology in Education
53	Koehler, M. J.	2005	Teachers learning technology by design	Journal of Computing in Teacher Education
53	Harris, J	2008	Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed	Journal of Research on Technology in Education
51	Koehler, M. J.	2007	Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology	Computers and Education

As seen from Table 3, it is commented that in the aspect of citation numbers in the studies about TPACK area, the document that has co-citation at the highest frequency is the most referenced study in the struggle of the theoretical definitions of the field. It is seen that M.J. Koehler is the most productive author in the list of the most citated documents. Computers and Education and Journal of Research on Technology in Education journals are evaluated as the ones in which the most citated documents are published. The documents that form the basic intellectual structure of the field are seen in the publication list that is formed by the citation frequency. But depending on the period, some studies can be citated intensely based on the examined subjects. These studies are determined by the Burst analysis. The burst publications that emerge in the document co-citations were given in Table 4.

Table 4. The Burst Publications that Emerge in the Document Co-Citations

Document	Publication Year	Activity Power	Beginning of the Period	End of the Period	Period
KOEHLER MJ,2005,J EDUC COMPUT RES, V32, P131-152	2005	7.6908	**2013**	2013	
NIESS ML,2005,TEACH TEACH EDUC, V21, P509-523	2005	5.4053	**2010**	2013	
CHAI CS,2013,EDUC TECHNOL SOC, V16, P31-51	2013	3.8447	**2014**	2015	
TONDEUR J,2012,COMPUT EDUC, V59, P134-144	2012	3.6549	**2014**	2015	
PAMUK S,2012, J COMPUT ASSIST LEAR, V28, P425-439	2012	3.6549	**2014**	2015	
KOH JHL,2010, J COMPUT ASSIST LEAR, V26, P563-573	2010	3.5163	**2013**	2013	
ERTMER PA,2005,ETR&D-EDUC TECH RES, V53, P25-39	2005	3.3889	**2011**	2013	
JANG S-J,2010,J SCI EDUC TECHNOL, V19, P553-564	2010	3.147	**2014**	2015	
HUGHES J,2005, J TECHNOLOGY TEACHER, V13, P277-302	2005	2.5253	**2012**	2013	
ANGELI C,2005,J COMPUT ASSIST LEAR, V21, P292-302	2005	2.4409	**2013**	2013	
MARGERUM-LEYS J,2004,J TEACH EDUC, V55, P421-437	2004	2.2953	**2011**	2012	
HEW KF,2007,ETR&D-EDUC TECH RES, V55, P223-252	2007	2.1605	**2014**	2015	
ERTMER PA,2010, J RES TECHNOLOGY ED, V42, P255-284	2010	2.1585	**2014**	2015	
ERTMER PA,2012,COMPUT EDUC, V59, P423-435	2012	2.1386	**2014**	2015	

When we consider the period of the burst documents, "Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge" by M. L. Niess, dated 2005 takes place in the literature as the document that draws attention the longest. *Teachers Learning Technology by Design* by M. J. Koehler, dated 2005, is the document that draws attention the most intensely. In the list of burst documents, P.A. Ertmer comes to the forefront as the author who has the maximum documents. When looked at the burst documents, from the basic studies about field, only M. L. Niess has a publication. The study that forms the first cognitive study about TPACK area does not seem in the burst analysis even though it is citated intensely. It is seen in the bibliography of the documents in the clusters that the study of Niess is a frequently used study by the studies that are actualized in the 2010-2013 periods which are about the examination and the theoretical development of the field. Similarly, Margerum-Leys' study is used intensely in these studies.

Conclusion, Discussion and Suggestions

Integration of technology into educational methods has been focused on as a subject by policy makers and researchers in the last decade. TPACK can be seen as an emerging subject in this manner. In this context there are studies on TPACK research (Kelly, 2010; Koh & Divaharan, 2011). However methods of these kind of studies are context analysis methods based on subject matter experts. With the

increase of the access to the scientific data bases, the access to the bibliographical information which belongs to the scientific studies became easier. Bibliometric methods are accepted as the methods that have the theoretical maturity which allows making the analyses and evaluations by the bibliographical data that is obtained from scientific data bases and without having a great expertness about the area. In this study TPACK research field has been investigated in a different way. This method does not need expertise and analysis are repeatable. In this study, the most prominent authors and scientific publications have been defined using citation analysis.

At the end of the study, it is aimed to detect the researchers and documents which are in intellectual leaders' positions about TPACK area, in the discipline of citation which is the most used one in academic communication. Citation and citation patterns express the notion that forms the structure in which the academicians communicate with each other via the documents in the structuralism theory context. With the help of specifying the pattern that is formed by its own interior dynamics, it has been possible to detect the new research focuses and the research topics that come to critical level in the scientific aspects. In some research (Chai et.al.,2013; Rosenberg and Koehler (2015) regarding TPACK a high level similarities between defined researchers and findings have been found. This similarity points out the consistency between bibliometric results and content analysis results. In addition bibliometrics can be used as an alternative in this manner when risks of other methods are considered. The clusters in the maps that have been formed as a result of the analysis are the clusters that are formed by the data mining methods rather than expert evaluations. The studies that are included by these clusters and the cluster titles reveal the general outlook in the context of examined topics. When the structure that is formed by the clusters is examined, Web applications, the unifying studies about technology integration and the struggles about TPACK area are seen as the mainly mentioned topics.

It is seen that the publications of the authors who defined TPACK area with different names in theory (Angeli & Valanides, 2009; Mishra & Koehler, 2006; Maggie L. Niess, 2005; Pierson, 2001) are the prominent in both author co-citation analysis and document co-citation analysis (Brantley-Dias & Ertmer, 2013). When the cognitive mapping structure about the field is considered, even though it is seen that the cognitive structure is dissociated in relevant levels from the aspect of clustering performance, it is seen that from the aspect of distinctiveness of elements of the clusters that emerged an adequate performance is not provided. In this context, it is possible to say that the theory is not mature enough and the sub-research areas which are separated from each other with exact borders depending on the explanation of the studies by applications have not emerged yet.

Only Wu (2013) study can be given as an example for evaluation based on bibliometric methods. Dataset of his study consisted of 24 publications indexed in SSCI (Social Science Citation Index) between 2002 and 2011 in WoS database. For this reason this study can be assumed as the research having the biggest dataset in this context. The cooperation pattern and the cooperation structure which belongs to the prominent authors and documents that is acquired in the conclusion of the study can be used as a guide which will form a beginning for future researches.

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