Studying relationships of technology in curriculum research: a network approach to connections and collaborations

Daniel Trugillo Martins Fontes[i]

Esdras Viggiano[ii]

André Machado Rodrigues[iii]

Cristiano Mattos[iv]

Abstract

This study aimed to characterize relationships in publications about Information and Communication Technologies (ICT) in the *e-Curriculum Journal* using Social Network Analysis (SNA) as a theoretical and methodological framework. From the SNA, three networks were constructed: (i) keyword co-occurrence, (ii) Higher Education institutions' collaborations, and (iii) coauthorship. The analytical results indicated an articulation between keywords, showing that ICT is in a central position with many connections without being isolated in specific niches. In addition, there was a predominance of work from public and private universities in the Brazilian Southeast region and collaboration with institutions geographically nearby. Alternatively, a highly fragmented coauthorship network shows the predominance of authors with doctoral degrees. Lastly, the networks formed are similar to those in other social research areas.

Keywords: social network analysis; information and communication technologies; scientific collaboration; curriculum; knowledge building.

[i] Ph.D. Candidate at the Interunit Graduate Program in Sciences Teaching of the University of São Paulo (USP). E-mail: daniel.fontes@usp.br – ORCID iD: https://orcid.org/0000-0002-4741-2067.

[ii] Ph.D. in Science Education from the University of São Paulo (USP). Adjunct Professor at the Institute of Natural and Exact Sciences and Education of the Federal University of Triângulo Mineiro (UFTM). Coordinator of the Research Group on Science Education and Educational Policies (PECPE). E-mail: esdras.viggiano@uftm.edu.br – ORCID iD: https://orcid.org/0000-0001-6165-8410.

[iii] Ph.D. in Science Education from the University of São Paulo (USP). Assistant Professor at the Institute of Physics of the University of São Paulo (USP). E-mail: rodrigues.am@usp.br – ORCID iD: https://orcid.org/0000-0001-7109-5295.

[iv] Ph.D. in Physics from the University of São Paulo (USP). Associate Professor at the Institute of Physics of the University of São Paulo. Head of the Research Group on Science Education and Complexity (ECCo). E-mail: crmattos@usp.br – ORCID iD: https://orcid.org/0000-0001-5927-8742.

Um estudo das relações da tecnologia na pesquisa em currículo:
uma abordagem de redes para as conexões e colaborações

Resumo

Este estudo teve como objetivo caracterizar as relações em publicações sobre Tecnologias de Informação e Comunicação (TIC) na Revista e-Curriculum utilizando a Análise de Redes Sociais (ARS) como referencial teórico-metodológico. A partir do ARS, foram construídas três redes: (i) coocorrência de palavras-chave, (ii) colaborações de Instituições de Ensino Superior e (iii) coautoria. Os resultados analíticos indicaram uma articulação entre as palavras-chave, mostrando que a TIC está em posição central com muitas conexões sem estar isolada em nichos específicos. Além disso, houve predominância de trabalhos de universidades públicas e privadas da região sudeste brasileira e colaboração com instituições geograficamente próximas. Alternativamente, uma rede de coautoria altamente fragmentada mostra predominância de autores com doutorado. Por fim, as redes formadas são semelhantes às de outras áreas de pesquisa das Ciências Sociais.

Palavras-chave*: análise de redes sociais; tecnologia da informação e comunicação; colaboração científica; currículo; construção de conhecimento.*

Un estúdio de las relaciones de la tecnología en la investigación del currículo:
un enfoque de redes para conexiones y colaboraciones

Resumen

Este estudio tuvo como objetivo caracterizar las relaciones en las publicaciones sobre Tecnologías de la Información y la Comunicación (TIC) en la Revista e-Curriculum utilizando el Análisis de Redes Sociales (ARS) como marco teórico y metodológico. A partir del ARS, se construyeron tres redes: (i) co-ocurrencia de palabras clave, (ii) colaboraciones de instituciones de educación superior y (iii) coautoría. Los resultados analíticos indicaron una articulación entre palabras clave, mostrando que las TIC se encuentran en una posición central con muchas conexiones sin estar aisladas en nichos específicos. Además, hubo predominio de trabajos de universidades públicas y privadas de la región Sudeste de Brasil y colaboración con instituciones geográficamente cercanas. Alternativamente, una red de coautoría altamente fragmentada muestra un predominio de autores con doctorado. Por fin, las redes formadas son similares a las de otras áreas de investigación de las Ciencias Sociales.

Palabras clave*: análisis de redes sociales; tecnología de la información y comunicación; colaboración científica; currículo; construcción de conocimiento.*

1 INTRODUCTION

Curriculum research is diverse, and an analysis of its development is currently important. In recent decades, this field has experienced growth in various directions, with debates and theoretical approaches that reflect a range of research objects, education levels, and ideological perspectives (Silva, 1999; Young, 2013). Understanding the evolution of

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations

2

curriculum research through its dynamics and relevance is crucial for advancing curricular knowledge. However, curriculum research has practical challenges, including areas lacking adequate attention. Recent changes in the national curriculum, combined with new Information and Communication Technologies (ICT) brought to the forefront by the global pandemic, demand a thorough reflection on the possible contributions, potentialities, and deficiencies of this research field.

In the early 2000s, ICT began influencing curriculum research since it impacted academic research (knowledge production), research themes (e.g., web curriculum), and curricula. According to Selwyn (2010), technologies, especially the Internet, have shaped the relationships between education and learning and influenced new forms of education. Most recently, the COVID-19 pandemic highlighted the importance of the Internet for pedagogical activities (Organisation for Economic Co-operation and Development [OECD], 2021; Santiago; Mattos, 2023). We need to overcome prejudices about integrating technology and school institutions, as recently demonstrated by Santiago and Mattos (2023), who used gaming communication software as a didactic tool. With technological changes, we cannot ignore that the ways of interaction and information exchange between people have been highly impacted (Selwyn, 2010; Santiago; Mattos, 2023).

In this study, we begin with the presumption that scientific production, in general, is impacted by the development of ICT. In particular, the Internet, where information is distributed and accessible rapidly, widely, and on-demand, has significantly influenced curricular research. In addition to its impact on scientific collaboration, the varieties of editorial boards and the increase in editorial flows in scientific publishing processes have led to a dizzying increase in the dissemination of scientific production. In addition to the modification of production and dissemination processes in science, ICT has influenced various areas of the educational field, especially with the development of mediating resources in teaching and learning processes (Matos *et al*., 2019; Paula, 2017), which have restructured pedagogical activities (Almeida *et al*., 2020) and affected several dimensions of these activities (Chizzotti, 2020). Therefore, it is important to examine how ICT is inserted into the field of curriculum from a social network approach.

In light of the influence of ICT on human activities, the growth of ICT within the field

of curriculum research has been continuous and apparent (Almeida *et al*., 2020; Evangelista; Sales, 2016). The increasing integration of these technologies in the curricular field of research and practice has resulted in a totality whose dialectical unity implies mutual transformations (Almeida; Valente, 2012). In this scenario, ICT has become part of new educational research agendas, such as classroom activities, virtual learning environments, distance education, open education, hybrid teaching, and education policies.

In this paper, we aim to examine how ICT has consolidated itself on curriculum research. Specifically, we aim to characterize the relationships expressed in publications on ICT in a well-known, peer-reviewed Brazilian Journal of Curriculum Research. This goal can be expressed by a research question: **What are the structures of the networks when considering ICT in curriculum research (ICT-CR) in the *e-Curriculum Journal*?** To address this research question, we produced and analyzed three types of networks: (i) keyword co-occurrence, (ii) Higher Education institutions, and (iii) coauthorship. We used Social Network Analysis (SNA) (Scott, 2012), which allowed us to explore the concepts of structure and position that characterize network analyses and their participants.

In a recent review, Almeida *et al*. (2020) introduce a critical analysis by revisiting Camas's (2010, p. 31) question: "What is the meaning of a journal?". Almeida *et al*. (2020) take up this challenge and explore the dialogue with different papers on curriculum and technology in the *e-Curriculum Journal*. Inspired by their work and the thematic issue "Curriculum and technologies: networks, territories, and diversities"[1], we approach the same object but ask a different question: "What are the networks of a journal?". As a result, this paper describes the organizational structure of some of the collaborative networks of the *e-Curriculum Journal*. It discusses the implications for ICT-CR concerning its territories and diversities.

2 SAMPLE, METHODS AND PROCEDURES

Our research methodology consisted of three major steps: data collection, standardization, and validation[2]. We followed some of the procedures proposed by Almeida *et al*. (2020) to identify and characterize the scientific output related to ICT in the *e-Curriculum*

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations

4

Journal. We use the Gephi software version 0.9.7 to build and evaluate the networks.

2.1 Data collection

We obtained the metadata directly from the *e-Curriculum Journal's* website. The choice of the *Journal* is justified by its importance to the field of research integrating the curriculum with ICT in Brazil (Evangelista; Sales, 2016) and by having an explicit focus on curriculum research. The data of all published documents was collected automatically through web scraping. Subsequently, we manually excluded reports, interviews, essays, reviews, or abstracts of published works, to keep only the research papers. The final sample included 830 papers published in the *e-Curriculum Journal* between 2005 and 2022.

2.2 Data standardization

In this stage, we focused on standardizing institutional affiliations and names, as an author's or institution's name may be presented differently throughout publications in the *Journal* (e.g., PUC-SP; PUC/SP; PUCSP [Pontifical Catholic University of São Paulo]). The authors' institutional affiliations were self-reported when they published the paper. The standardization process was mostly manual and involved putting acronyms in accordance with the latest Higher Education Census of 2021 in most cases. For the remaining cases (less than 5%), we followed the criteria inspired by Barros (2020):

I) When an author was affiliated with two (or more) institutions, the affiliation corresponding to the Higher Education Institution (HEI) prevailed.

II) When an author was affiliated with two (or more) HEIs, and in one of them, he/she was a graduate student, we kept the HEI in which the author was a professor.

III) When an author was affiliated with two (or more) HEIs, but he/she did not inform the specificity of the affiliation, we kept the HEI presented first in the author's description.

IV) Non-Brazilian HEIs were grouped under the name of the country they belong to (e.g., the University of Minho and the University of Lisbon were grouped under 'Portugal').

Exceptional cases not covered by the previous criteria were individually verified in the researchers' Lattes curriculum[3] to inform the most reliable affiliation possible at the time of the paper's publication. The authors' institutional information (e.g., student, professor) was also obtained from the reported metadata or as informed in the Lattes curriculum, if needed, following the approach used by Simões *et al*. (2020).

2.3 Data validation

We conducted an independent categorization process for the keywords. Firstly, we assumed that the keywords listed in the front matter of the papers are related to the topic being discussed (Calma; Davies, 2015; Melo *et al*., 2016). Thus, we identified the keywords related to technology since the relationship with the curriculum is expressed in the editorial policy of the *e-Curriculum Journal*, and "[...] all the publications address issues related to it" (Almeida *et al*., 2020, p. 620). In doing so, two of the authors independently analyzed all the keywords and marked those related to technology in a broad sense. This process yielded a statistically significant result[4]. The second step involved another author of the current study reviewing the cases of disagreement in the context of each paper and compiling all of the publications that addressed the issue of ICT and curriculum into a final list. A paper would be classified as addressing ICT if it had at least one ICT-related keyword (71 papers had one ICT keyword, 60 papers had two ICT keywords, 20 papers had three ICT keywords, and six papers had four ICT keywords).

It is worth noting that the *e-Curriculum Journal* indicates two dictionaries of terms (the Brazilian Thesaurus of Education and the UNESCO Thesaurus). However, the authors often do not use them to include their respective keywords. Some "keywords" are several terms grouped (e.g., 'teaching of African and Afro-Brazilian history and culture'). When applicable, the keywords were also standardized: plurals, typing errors, translations, and specificities that we considered unnecessary and did not affect the analysis were grouped to provide a more accurate analysis of the discussed themes.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
6

2.4 Data evaluation: network analysis metrics

According to Scott (2012, p. 1), SNA "[...] takes the metaphorical idea of interaction as forming a network of connections and gives this idea a more formal representation to model structures of social relations". SNA is usually based on graph theory (Wasserman; Faust, 1994). Graphs are defined as a set of nodes (points or vertices) connected in pairs by edges (or lines). The roles of both nodes and edges can vary depending on the study. In this work, the nodes represent keywords, HEIs, or researchers, as explicitly stated in each case, while the edges represent connections between them. For instance, two HEIs are connected in the network if they appear together in the same paper. As the edges are based on coauthorship, they are undirected, with no preferred direction connecting two nodes.

Additionally, we assign weight to the edges so that their thickness can be associated with the number of connections between two nodes, indicating greater connection through a thicker edge. Next, we present a list of concepts used to study the networks, followed by a brief explanation. Further information about them can be found in the cited references.

I) *Degree centrality*. The degree centrality (also called just 'degree') of a node in a network is the total number of other nodes to which it is connected. For instance, a node with degree centrality 4 implies that it is connected to four other nodes. This is the most straightforward measure of a network (Scott, 2012).

II) *Betweenness centrality*. The betweenness centrality is the frequency with which a node is located on the shortest path between two other nodes (Wasserman; Faust, 1994). In a knowledge-based network, such as a coauthorship network, this measure indicates the power to control the flow of information.

III) *Closeness centrality*. The closeness centrality indicates the position of a point in the network based on the distance from all other nodes. Yan and Ding (2009, p. 1603) state that this metric expresses "how long it will take information to spread from a given vertex to others in the network". Thus, nodes with high closeness centrality travel shorter distances to reach all other nodes in the network.

IV) *Connected components*. The connected components represent subgroups of nodes connected to each other but disconnected from the rest of the network. The largest of these

subgroups is called the giant component (Mena-Chalco *et al*., 2014). It is a concept that allows us to evaluate the overall connectivity of the network.

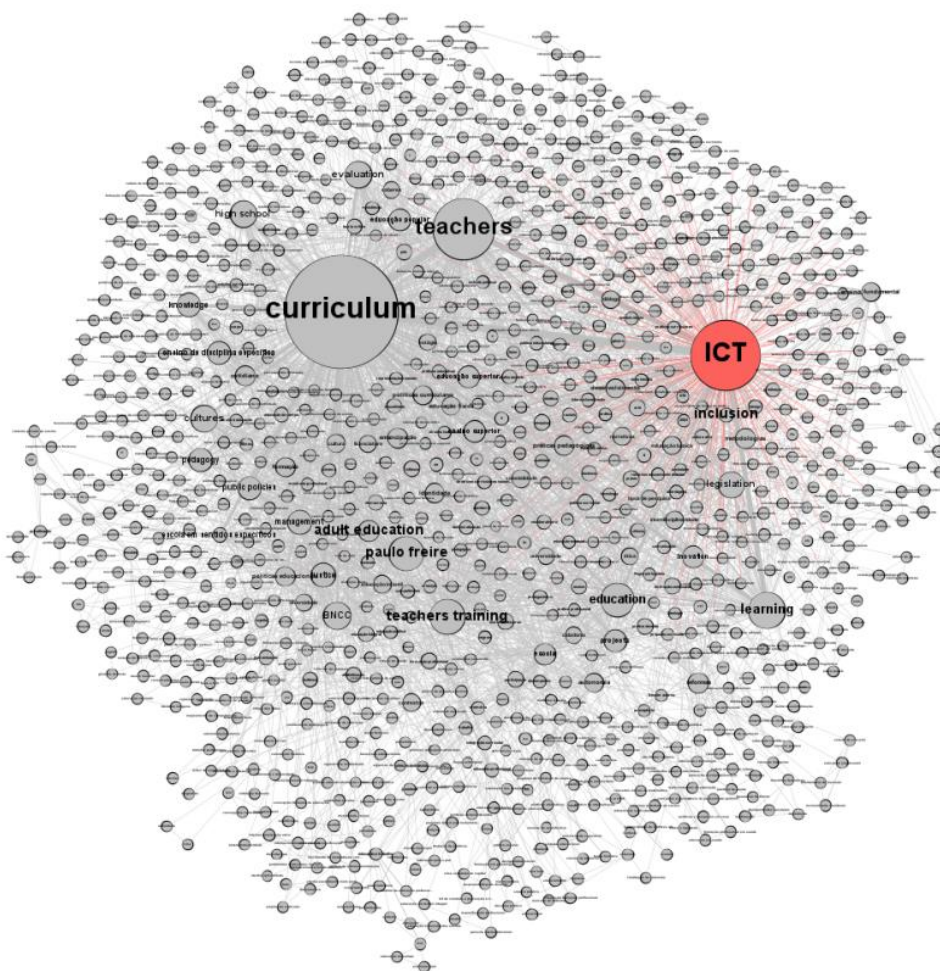## 3 GENERAL RESULTS: KEYWORD CO-OCCURRENCE NETWORK

Altogether, we identified 830 papers published in the *e-Curriculum Journal* until 2022. They are from hundreds of institutional affiliations from all regions of Brazil and abroad. Of the analyzed papers, 157 (18.9%) correspond to ICT research. Researchers from more than 50 HEIs authored these papers. Figure 1 shows the temporal evolution of the number of papers classified as ICT-CR and non-ICT-CR published over the years.
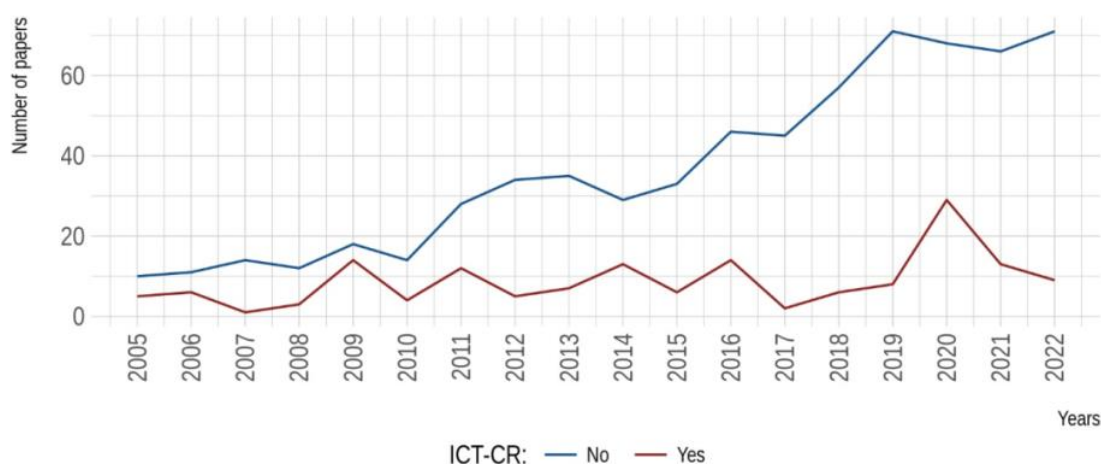
Figure 1 – The number of ICT-CR (red line) and non-ICT-CR (blue line) papers in the *e-Curriculum Journal*
Source: The authors.

Next, Figure 2 shows the giant component of the keyword co-occurrence network formed by the 830 papers, with 1,117 nodes and 3,863 edges.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
8

Figure 2 – Giant component of the keyword co-occurrence network for the papers in the *e-Curriculum Journal*
Source: The authors.
Caption: the ICT keyword is highlighted. The size of the nodes is proportional to the degree of centrality.

Although the keywords lack uniformity, the extensive range of themes reflects the diversity of approaches, theories, objects, and levels of education that the *Journal* covers while maintaining its curriculum scope. Table 1 presents the top ten most common keywords and their respective centrality metric values used to assess the network structure. The giant component, which makes up 94% of the nodes and 97% of the edges in the network shown in Figure 2, was used to calculate the centrality metrics.

Table 1 – The ten most frequent keywords and their respective network metrics

| Keywords[5]	Frequency	Degree centrality	Betweenness centrality*	Closeness centrality*
curriculum	297	392	0.41	0.61
ICT	276	226	0.20	0.53
teachers	118	194	0.12	0.53
learning	61	101	0.04	0.49
Paulo Freire	48	93	0.06	0.48
evaluation	42	63	0.03	0.46
education	40	89	0.05	0.47
legislation	34	61	0.03	0.47
teachers training	32	95	0.05	0.49
cultures	29	63	0.03	0.46

Source: The authors. *The centrality values are normalized to the interval between 0 and 1.

The most frequent keyword is 'curriculum,' which has the highest values for all three centrality metrics. Although this is an expected result, given the scope of the *Journal*, this is a positive finding, as it acts as a triangulation of the data (Braga; Pereira; Rôças, 2022). Besides 'curriculum', both 'ICT' and 'teachers' maintain a prominent position in the network. That is, they are not only the most frequent in absolute terms, but they also make more connections (degree centrality), connect multiple other keywords (betweenness centrality), and occupy more central positions in the network (closeness centrality). Keywords following the top three may change ranking position according to metrics, which requires careful interpretation. For example, 'teachers training' makes more connections and occupies a more central position in the network despite its low frequency. At the same time, 'evaluation' appears more frequently in the papers but does not have high centrality metrics.

The keyword co-occurrence network reveals asymmetries and gaps in the curriculum research field. This either shows gaps in the field or that the analyzed *Journal* seems to privilege specific perspectives, expressed implicitly or explicitly in the scope of the editorial policy and reflected in the publications. In this regard, we highlight Early Childhood Education and Adult Education, which are not high-frequency topics. This corroborates the idea that these themes

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
10

do not receive as much attention in academic research as other themes (Braga; Pereira; Rôças, 2022; Poloni; Silva, 2020).

The ICT keyword stands out in the papers analyzed in the *Journal*. Its relevance justifies a more detailed analysis of its connections. Figure 3 shows the co-occurrence network of keywords related to ICT. This type of network is called 'ego network' because all points in the network are connected, directly or indirectly, to a particular node called 'ego'. The ego is 'ICT,' and the other nodes are 'alters' (Everett; Borgatti, 2005).
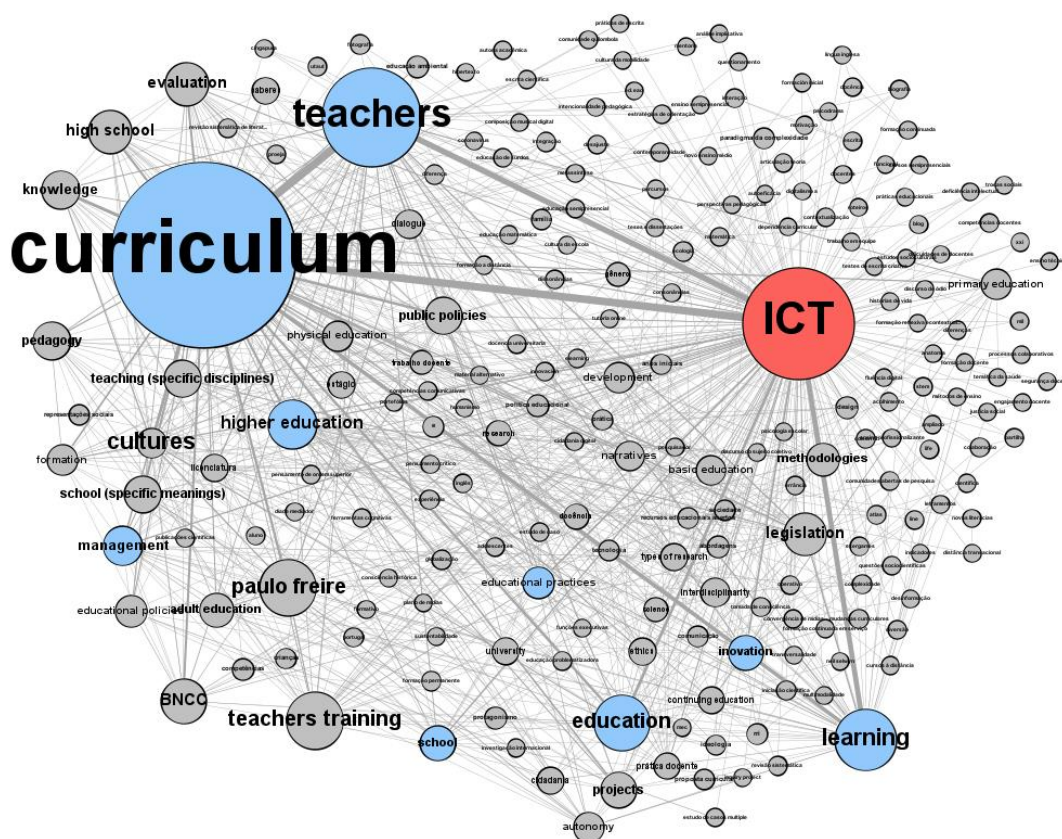
Figure 3 – Ego keyword co-occurrence network for ICT in the *e-Curriculum Journal*
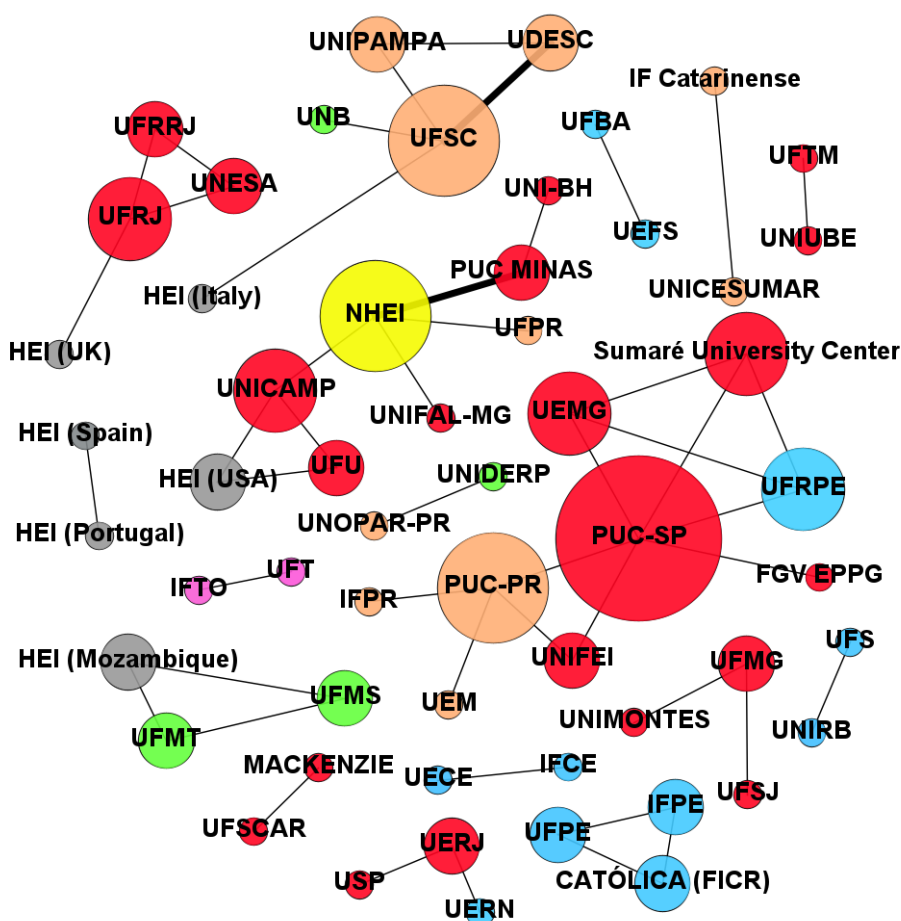Source: The authors.
Caption: the ego is highlighted in red, and the most frequent keywords connected to ICT are highlighted in blue ('curriculum', 'teachers', 'higher education', 'education', 'learning', 'innovation', 'educational practices', 'management, school'). The size of the nodes indicates degree centrality.

Excluding ICT, the keyword 'curriculum' appears with the highest degree centrality, followed by 'teachers', 'learning', 'higher education', 'teachers training', 'education',

'evaluation', and 'innovation'. At the same time that these words show their importance, the absence of others in central positions shows asymmetry in the network. For example, 'higher education' appears well-connected to ICT in the ego network, but there is a lack of words such as 'elementary school' and 'early childhood education'. Restricting the network of keywords to the ego network, we find that ICT directly connects to 20% of the total nodes and 24% of the total edges, signifying its crucial role in the network. Moreover, if we allow indirect connections to ICT, through one keyword that intermediates the connection, then the ego network reaches 86% of the nodes and 91% of the edges. This indicates that 85% of the keywords in the analyzed papers are at most two edges away from ICT.

4   COLLABORATION RESULTS: AFFILIATIONS AND COAUTHORSHIP NETWORKS

In this section, we discuss the structure of the ICT-CR network based on the links between affiliations and researchers. We begin with a macro perspective by examining the relationships between institutions. Figure 4 illustrates the network formed by the affiliations reported by the authors of the ICT-CR papers, which consists of 56 nodes and 48 edges. It is worth noting that non-HEI affiliations are designated as NHEI, and nodes representing foreign countries include more than one HEI.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
12

Figure 4 – Collaboration network of the HEIs for ICT-CR in the *e-Curriculum Journal*
Source: The authors.
Caption: colors are associated with Brazil's major regions (red – Southeast; blue – Northeast; green – Midwest; pink – North; orange – South). Gray nodes represent non-Brazilian HEIs. The yellow color represents all NHEIs. The size of the nodes indicates the degree of centrality. Nodes without inter-institutional connections and edges representing self-connections are not shown.

The geographic distribution of HEIs in Figure 4 is as follows: 22 in the Southeast region; 11 in the Northeast region; 10 in the South region; four in the Midwest region; and two in the North region. Table 2 reports the types of collaborative relationships among the various institutions illustrated in Figure 4. Although minor in relative numbers of cases, international collaboration in ICT-CR follows other areas of education (Akbaritabar; Barbato, 2021) and science (Souza; Barbastefano; Lima, 2012).

Table 2 – Types of relationships among HEIs for ICT-CR in the *e-Curriculum Journal*
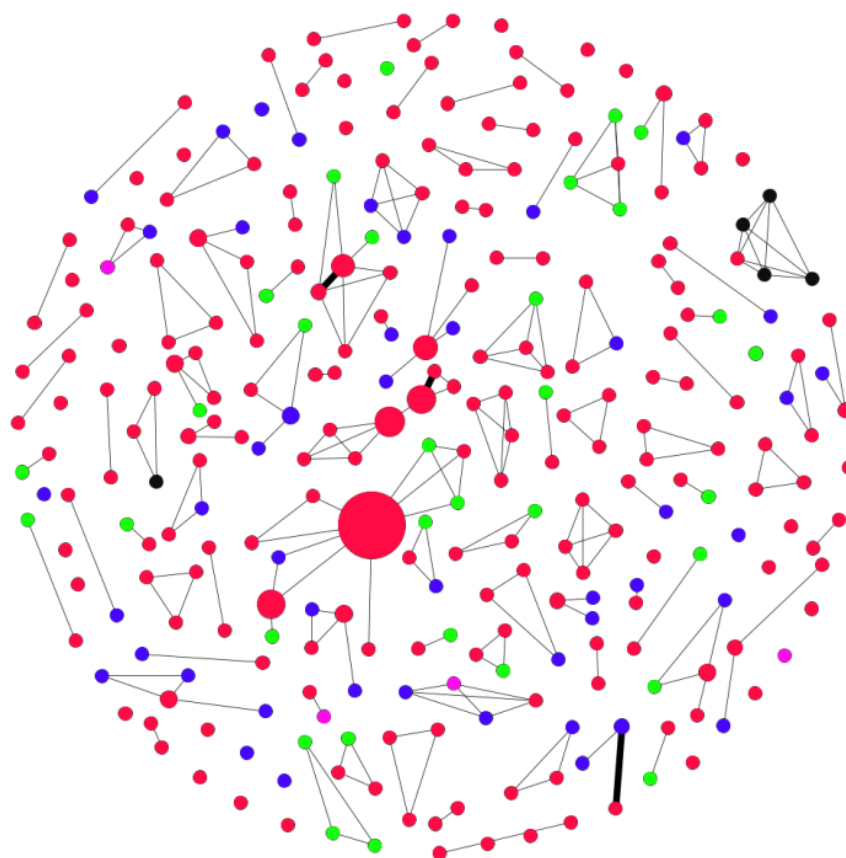
Relationship	2005-2013	2014-2022	Total
Inter-institutional*	7 (12.3%)	45 (45%)	52 (33.1%)
No collaboration (intra-institutional)	22 (38.6%)	37 (37%)	59 (37.6%)
No collaboration (single-authored paper)	28 (49%)	18 (18%)	46 (29.3 %)
Total	57 (100%)	100 (100%)	157 (100%)

Source: The authors.
* The 52 papers with inter-institutional collaboration are composed of intra-state collaboration (17 papers), inter-state collaboration (nine papers), international collaboration with Brazil (five papers), international collaboration without Brazil (15 papers), and collaboration between HEIs and NHEIs (six papers).

Table 2 shows that the frequency of collaboration between affiliations is inversely proportional to the geographic distance. In other words, the farther the HEIs are located, the lower the frequency of their collaboration. Additionally, we found that intra-institutional collaboration remained constant across the analyzed periods. The periods were grouped to include the same number of years.

Regarding the authors of ICT-CR papers, a total of 321 authors were identified, out of which 285 were single-authored papers. The average number of authors per paper was 1.8 between 2005 and 2013 and 2.2 between 2014 and 2022. Considering the entire period, the average number of authors per paper is 2.04. Single-authored papers accounted for 29% of the total, while the others resulted from collaboration. Among coauthored papers, 91% had two or three authors. It is worth noting that the *Journal's* editorial policy currently allows a maximum of four authors per paper, but it is unclear when this policy was implemented. The coauthorship network of the ICT-CR papers is presented in Figure 5, which shows 123 connected components (including single-authored papers) with a total of 285 nodes and 226 edges.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
14

Figure 5 – Coauthorship network for ICT-CR in the *e-Curriculum Journal*
Source: The authors.
Caption: colors are associated with institutional affiliation (red – college professors or PhD scholars; blue – students; pink – students and college professors at the same time; black – unrecoverable or not reported; green – others). The size of the nodes indicates betweenness centrality.

The 285 authors who make up the coauthorship network may be classified into five groups: 46 were exclusively students, mostly graduate students; 198 were exclusively professors at HEIs or researchers with a doctoral degree; four were graduate students and college professors at the same time; and 32 were classified in the 'other' category, comprising researchers with a master's degree and/or professors at institutions that were not at the Higher Education level. Five authors' affiliations were either unrecoverable or not reported[6].

Several characteristics of the coauthorship network stand out. First, it is highly fragmented, with many connected components. Each connected component is a set of researchers who have collaborated among themselves but have not collaborated with the rest of

the network. The connected giant component has just 3.5% of the network's nodes. Second, the vast majority (93.3%) of the researchers have a betweenness centrality equal to zero, which means that they do not intermediate the flow of information among other researchers. Third, around half of the edges (48%) connect professors at HEIs or researchers with doctoral degree. Fourth, 16% of the nodes represent graduate students, and their collaboration (student-student connections) corresponds to approximately 2% of all edges. Finally, just over a quarter (27%) of the ICT-CR papers are coauthored by graduate students.

5 GENERAL DISCUSSION

The present study analyzes bibliometric and relational data from the ICT network in curricular research. Although the *Journal* has published a significantly higher number of non-ICT-CR papers since 2010, the number of ICT-CR papers has remained relatively stable at around 10 per year, with an average of 9 for the entire period (see Figure 1). The number of ICT-CR publications gradually increased over time, with some significant peaks, including in 2020 when the *Journal* published a theme issue on web curricula. However, while the production of ICT-CR papers has remained somewhat consistent, the percentage of total publications focused on ICT has decreased from about one-third in 2005 to 12.5% in 2022. Therefore, our data suggest that the growth in the number of papers published in the *Journal* has been more significant in the non-ICT-CR category.

The previous results indicate that technology in the curriculum remains a consistent topic of discussion among researchers, as Almeida *et al.* (2020) have noted. However, we consider the stability in the quantity of ICT-CR papers somewhat unexpected, given the increasing popularity of new ICT and the trend towards implementing, studying, and integrating them in education research (Albino; Souza, 2016; Paula, 2017). It was also expected that the quantity of ICT-CR papers would reflect the growing discussions of curricular reforms in Brazil, such as the National Common Core Curriculum (*Base Nacional Comum Curricular – BNCC*), which emphasizes ICT competencies and skills (Fiori; Goi, 2021). Similar trends are seen abroad, focusing on designing curricula to address technological transformation (Capuk, 2015; Jamieson-Proctor *et al.*, 2006; Pinar, 2003; Zhang; Zhang; Wang, 2020).

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
16

The prominent position of the ICT (see Table 1) with the quantity of ICT-CR papers in Figure 1 implies that ICT-CR papers use more than one term related to ICT for indexing purposes. We emphasize that ICT is not a single keyword but encompasses a set of terms for information and communications technology. Stated differently, although there are relatively few ICT-CR papers (18.9%) in the overall count of the *Journal*, the ICT keyword has many relationships, acting as an important mediator between themes and being in a central position in the network as a whole. Such a result indicates that the ICT theme does not form a particular niche of topics in a specific connected network component, in which it would be highly connected with other technology-related topics but weakly connected with more general topics.

The ego ICT network also shows a strong connection between ICT and 'teachers.' This relationship indicates that the use of ICT in education is closely linked to teacher training and professional development, which is consistent with international research on the subject (see Scherer; Teo, 2019). Additionally, the 'learning' keyword is also highly connected to 'ICT', indicating that the use of technology in education is not only related to teaching but also to student learning. The ego network also shows a strong connection between ICT and 'innovation', highlighting the importance of technology in promoting educational innovation.

Overall, these findings suggest that the use of ICT in curriculum research is not only a technical issue but also a pedagogical one that involves teacher training, student learning, and educational innovation. Therefore, given the characteristics that the ICT node assumes in the keyword co-occurrence network, we argue that the ICT theme permeates various discussions related to teachers, learning and education, among other broad topics. We advise interested readers to consult Almeida *et al*. (2020) for an in-depth discussion on how the papers discuss ICT concerning these themes in the *e-Curriculum Journal*.

6 DISCUSSING THE COLLABORATION NETWORKS

The prevalence of HEIs from the Southeast region is notable in the ICT-CR scientific collaboration network. This finding can be interpreted in two main ways. Firstly, it could be attributed to the *e-Curriculum Journal* being edited by PUC-SP, a Higher Education institution in São Paulo, making the São Paulo region a hub for universities. The network presented in

Figure 4 displays five universities in the São Paulo metropolitan area (PUC-SP, Mackenzie, Sumaré University Center, University of São Paulo – USP, Getulio Vargas Foundation – FGV). Additionally, it is crucial to consider that the Southeast region comprises 43% of the universities in Brazil (Brasil, 2022) and a more significant number of academic graduate programs, which are directly associated with academic production in Brazil (Mezzadri *et al.*, 2021). HEIs from the Southeast region also dominate other educational research areas (see Hayashi *et al.*, 2008). Particularly, PUC-SP is followed by institutions such as the State University of Campinas (UNICAMP), Federal University of Santa Catarina (UFSC), State University of Minas Gerais (UEMG), Federal University of Rio de Janeiro (UFRJ), Federal Rural University of Pernambuco (UFRPE) and Pontifical Catholic University of Paraná (PUCPR), demonstrating a predominance of publications in public institutions. However, some private institutions are also significant in the network.

An interesting finding derived from collaborations between educational institutions is a notable predominance of ICT-CR production in universities, although some university centers and Federal Institutes are also present. This reinforces the notion that scientific production in Brazil occurs primarily in older and well-established institutions that have achieved the maximum level of autonomy, as stipulated by the *Lei de Diretrizes e Bases da Educação Nacional* (LDB) [National Education Guidelines and Framework Law] (Brasil, 1996). Among private institutions, there is a preponderance of Pontifical Catholic Universities (PUC-SP, PUCPR, PUC Minas) and other universities that were founded over 30 years ago, such as Mackenzie (1870), UNIUBE (1947), *Centro Universitário de Belo Horizonte* –UNIBH (1964), *Universidade Norte do Paraná* – UNOPAR (1972), *Universidade para o Desenvolvimento do Estado e da Região do Pantanal* – UNIDERP (1974) and UniCesumar (1990). The Federal Institutes emerged from the significant expansion of Higher Education at the end of the 2000s, with many institutions being created or transformed from Technological Centers into Federal Institutes, offering undergraduate courses, many of them in Education. This indicates that, despite having less tradition in Higher Education than federal and private institutions, Federal Institutes are actively engaged in ICT-CR.

The results of our study align with the perspective of Carvalho *et al.* (2021) in contextualization in Science-Technology-Society (STS) research. The authors argue that HEIs

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
18

collaborate very little among themselves. Similarly, we also found that most ICT-CR occur without collaboration between institutions. However, despite this being the majority, there is a temporal trend of collaboration between institutions, which is not always observed in the fields of Humanities or Social Sciences (see Gazda; Quandt, 2010). The trend of inter-institutional collaboration may reflect the inter, multi, and transdisciplinary aspects of ICT-CR, leading scholars to seek partnerships outside their local institution.

Perhaps researches on contextualization in STS, or more generally, those that do not observe a trend of inter-institutional collaboration, are more focused on local problems, experiences, and particular realities of the subjects of a specific location or region, which may not favor collaboration between HEIs as much as ICT-CR does. Let's consider that there are research topics that are closer to experience reports (e.g., didactic interventions) than others (e.g., comparative education). It seems reasonable to assume that these research topics will present different patterns of inter-institutional collaboration due to their own object of study. One hypothesis that can be inferred from this and deserves specific analysis is that ICT-CR has research agendas that favor inter-institutional collaboration compared to other educational areas. Such information would broaden our understanding of the ICT-CR field of study, but it would go beyond our current goals.

Overall, the findings suggest a consistent quantity of intra-institutional collaboration. This is consistent with previous studies that have also observed significant levels of intra-institutional collaboration in various research areas in Brazil (see Costa; Pedro; Macedo, 2013; Souza; Barbastefano; Lima, 2012). The share of intra-institutional research may fluctuate around a minimum threshold over the years (in our case, around 37%) due to geographic proximity and human factors related to academic research, such as familiarity with coauthors and trust involved in the research (Cantner; Hinzmann; Wolf, 2017; Glückler; Lazega; Hammer, 2017).

In addition, NHEIs only represent 4% of the sample but have a relatively high degree of centrality. This is not surprising as NHEI is not a single institution from a determined geographic location but encompasses boards of education in 'Minas Gerais', 'Santa Catarina', 'Rio Grande do Norte'. Therefore, it increases the possibility of connections with different HEIs. Even though the number of authors with NHEI affiliations who publish in collaboration

with college professors is small, it highlights the importance of not only looking at the frequency of their appearance in papers but also at the network of production and dissemination of knowledge.

6.1 The coauthorship network

The bibliometric authorship indexes of ICT-CR suggest scientific collaboration growth and a predominance of papers with two or three authors. These results are not surprising as coauthorship is a trend in various areas of scientific research, both in Brazil (Dias; Moita; Dias, 2019; Mena-Chalco *et al*., 2014) and internationally (Campbell; Simberloff, 2022), including subareas of education such as science education (Fontes; Rodrigues, 2024) or research grounded in specific theoretical frameworks such as cultural-historical activity theory (Fontes; Rodrigues, 2023a). The high proportion of ICT-CR papers with two or three authors is also observed in technological education (Zervas *et al*., 2014), electromagnetism education research (Fontes *et al*., 2023), and in areas of Applied Social Sciences (Gazda; Quandt, 2010). Therefore, we argue that ICT-CR in the *e-Curriculum Journal* demonstrates authorship indexes that align with what is expected for a mature field of research in the humanities knowledge area.

Regarding the coauthorship network, the production of scientific knowledge related to ICT-CR displays a variety of profiles. Approximately 16% of coauthors are students, representing 27% of the network connections. This suggests that ICT-CR in the *e-Curriculum Journal* does not have a significant high expression of student coauthors, which differs from other types of research in the educational field (see Fontes; Rodrigues, 2023b). On the other hand, students rarely publish alone, and college professors or doctoral scholars are present in all collaboration relationships. This indicates a distance between ICT-CR and researchers who are not college professors or have not obtained a doctoral degree. It is worth noting that in Brazil, Basic Education teachers often lack the conditions to pursue "*stricto sensu*" graduate degrees, making it difficult for them to become committed researchers. Moreover, professional careers in Basic Education often value teaching experience over research production in the form of academic papers. Finally, the predominance of papers produced by doctoral scholars is acknowledged, as they are more productive and tend to stay longer in the field.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations

20

When considering the large number of connected components and the low percentage of authors with non-zero betweenness centrality, it is apparent that ICT-CR in the *Journal* is fragmented, with researchers working mainly in isolated groups. Other researchers have also reported high fragmentation in coauthorship networks in specific areas of knowledge (e.g., Bitzenbauer, 2021; Carvalho *et al*., 2021; Fontes *et al*., 2023). On the other hand, Almeida *et al*. (2020) have identified a set of themes and subcategories in ICT-CR in the *Journal*, which may aid in understanding the fragmentation of the network. As a corollary of the fragmented network and the presence of very few authors in each connected component, ICT-CR in the *Journal* lacks central authors who can mediate information between them or shape the structure and dynamics of the network in general. In other words, most authors in the network have zero betweenness centrality, meaning that they are not in a privileged position among other points, and information is exchanged within their respective connected components without noise, distortion, or control.

7 LIMITATIONS AND FUTURE RESEARCH

The present empirical work has two main limitations when assessing the results. Firstly, the sample only consists of papers in the *e-Curriculum Journal*, one of Brazil's primary technology journals for curriculum research. Although this narrow focus makes the findings relevant to the *Journal's* audience and scholars in the interdisciplinary field of ICT and curriculum research, future work could broaden the scope to include more journals or databases to expand the dialogue presented here. This would allow for a better understanding of how the *e-Curriculum Journal* compares to other journals with similar profiles and enrich our understanding of the ICT-CR field. Secondly, this work uses 'ICT' as a theoretical umbrella encompassing different perspectives in information and communication technology research. Future research may consider separating ICT into its respective collaboration networks and keyword co-occurrence networks to obtain more fine-grained results. Future studies could explore how intra-institutional relationships are influenced by links between graduate students and their advisors. Additionally, it may be worthwhile to investigate whether inter-institutional collaborations reflect graduate students moving to other educational institutions while

maintaining contact with their home institution advisors.

8 CONCLUSION

This study enhances the knowledge of the informational and communication technology area by considering one important aspect of its research: curriculum research. The objective was to characterize collaboration relationships in the *e-Curriculum Journal*, which contributes with specific insights to the thematic issue "Curriculum and technologies: networks, territories and diversities". The study discussed some networks' structures and their implications for ICT-CR regarding territories and diversities.

Through this work, important lessons have been learned, for instance, regarding diversities, the variety in the themes of the papers, as perceived with the help of the co-occurrence keyword network, reflects the diversity of approaches, theories, objects, and levels of education that the *Journal* can encompass while maintaining the scope of the curriculum. Specifically, the vast majority of themes are at most two connections away from ICT keyword, demonstrating the central position ICT-CR holds in the *Journal*. Consequently, the ICT theme is not confined to a specific niche in an isolated connected component but instead establishes numerous relationships with other themes, acting as an essential mediator and positioning itself in a privileged position in the network. The diversity of research is also reflected in the coauthorship relations, where various profiles can be identified in the production of scientific knowledge related to ICT-CR, involving a heterogeneous set of researchers, including college professors, doctoral and master's students, Basic Education teachers, and others.

Regarding territories, HEIs are prevalent in the Brazilian Southeast region, mostly older and well-established public and private institutions. While non-Brazilian institutions and Federal Institutes also appear in the network, they are less prominent. As for geographical proximity, ICT-CR in the *Journal* features collaborative relationships among HEIs that decrease as distance increases, with multiple factors contributing to this phenomenon. Notably, there has been an increase in inter-institutional collaborations over time, indicating that ICT-CR in the *Journal* is expanding its boundaries, including international collaborations. It is important to note that inter-institutional and intra-institutional relationships are positive for a

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
22

research field. As Ansell, Lundin, and Öberg (2017, p. 316) have stated, "although geographical proximity is understood to enhance interactional learning, nonlocal networks are increasingly understood to be important for preventing local learning networks from becoming too parochial".

In conclusion, while ICT-CR may be considered a specialized field within the subarea of curriculum, which is itself a subarea of education, it shares similar characteristics with other knowledge areas at different levels of specialization and research tradition. Our investigation of ICT-CR through social networks has highlighted the crucial roles that network structure and geographical proximity play in understanding this field of research. However, there is much more to be explored regarding how modes of presence (such as being in the same institution) and connections (such as between students and advisors) are intertwined in producing scientific knowledge. The present research provides a foundation for further inquiry into the relationship between Informational and Communication Technology and Curriculum Research.

9 ACKNOWLEDGMENTS

REFERENCES

AKBARITABAR, Aliakbar; BARBATO, Giovanni. An internationalised Europe and regionally focused Americas: A network analysis of higher education studies. **European Journal of Education**, v. 56, n. 2, p. 219-234, 2021. DOI: https://doi.org/10.1111/ejed.12446. Accessed on: March 10th, 2023.

ALBINO, Raphael; SOUZA, Cesar Alexandre de. Avaliação do nível de uso das TICs em escolas brasileiras: uma exploração dos dados da pesquisa 'TIC EDUCAÇÃO'. **Revista Economia & Gestão**, Belo Horizonte, v. 16, n. 43, p. 101-125, 2016. DOI: https://doi.org/10.5752/P.1984-6606.2016v16n43p101. Accessed on: March 10th, 2023.

ALMEIDA, Maria Elizabeth Bianconcini; PERRIER, Gerlane Romão Fonseca; GONÇALVES, Lina Maria; MUÑOZ, Cleide Maria dos Santos. Curriculum and technology: systematic literature review within the domain of the e-Curriculum Journal. **Revista e-**

Curriculum, São Paulo, v. 18, n. 2, p. 614-635, 2020. Retrieved from: https://revistas.pucsp.br/curriculum/article/view/48104. Accessed on: March 10th, 2023.

ALMEIDA, Maria Elizabeth Bianconcini; VALENTE, José Armando. Integração currículo e tecnologias e a produção de narrativas digitais. **Currículo sem Fronteiras**, [*s. l.*], v. 12, n. 3, p. 57-82, 2012. Retrieved from: https://sgmd.nute.ufsc.br/content/especializacao-cultura-digital/biologia-em2/medias/files/almeida-valente.pdf. Accessed on: March 10th, 2023.

ANSELL, Christopher; LUNDIN, Martin; ÖBERG, Per Ola. Learning networks among Swedish municipalities: is Sweden a small world? *In*: GLÜCKLER, Johannes; LAZEGA, Emmanuel; HAMMER, Ingmar (ed.). **Knowledge and networks**. Nova York: Springer, 2017. p. 316-336.

BARROS, Lucas Guimarães. **Uma análise cienciométrica da produção acadêmica sobre ensino de ciências em espaços não formais em periódicos e eventos da área (2008-2019)**. 2020. Dissertation (Doctoral in Education for Science) – Universidade Estadual Paulista, Bauru, 2020.

BITZENBAUER, Philipp. Quantum physics education research over the last two decades: A bibliometric analysis. **Education Sciences**, n. 11, p. 1-20, 2021. DOI: https://doi.org/10.3390/educsci11110699. Accessed on: March 10th, 2023.

BRAGA, Eduardo dos Santos de Oliveira; PEREIRA, Marcus Vinicius; RÔÇAS, Giselle. Análise de redes sociais dos artigos sobre Educação de Jovens e Adultos publicados nos últimos vinte anos do Boletim de Educação Matemática. **Bolema: Boletim de Educação Matemática**, Rio Claro, v. 36, p. 1023-1043, 2022. DOI: http://dx.doi.org/10.1590/1980-4415v36n74a04. Accessed on: March 10th, 2023.

BRASIL. Lei nº 9.394, de 20 de dezembro de 1996. Estabelece as diretrizes e bases da educação nacional. **Diário Oficial da União**: seção 1, Brasília, DF, n. 248, p. 27833-27841, 23 dez. 1996.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. **Sinopse Estatística da Educação Superior 2021**. Brasília: Inep, 2022. Retrieved from: https://www.gov.br/inep/pt-br/acesso-a-informacao/dados-abertos/sinopses-estatisticas/educacao-superior-graduacao. Accessed on: March 10th, 2023.

CALMA, Angelito; DAVIES, Martin. Studies in Higher Education 1976-2013: a retrospective using citation network analysis. **Studies in Higher Education**, v. 40, n. 1, p. 4-21, 2015. DOI: https://doi.org/10.1080/03075079.2014.977858. Accessed on: March 10th, 2023.

CAMAS, Nuria Pons Vilardell. Revista e-Curriculum: origem e evolução de um periódico científico eletrônico na área de educação e currículo construído na colaboração pedagógica. **Revista e-Curriculum**, São Paulo, v. 6, n. 1, 2010. Retrieved from: https://revistas.pucsp.br/curriculum/article/view/6636. Accessed on: March 10th, 2023.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations

24

CAMPBELL, Sara E.; SIMBERLOFF, Daniel. Forty years of invasion research: more papers, more collaboration... bigger impact? **NeoBiota**, v. 75, p. 57-77, 2022. DOI: https://doi.org/10.3897/neobiota.75.86949. Accessed on: March 10th, 2023.

CANTNER, Uwe; HINZMANN, Susanne; WOLF, Tina. The coevolution of innovative ties, proximity, and competencies: Toward a dynamic approach to innovation cooperation. *In*: GLÜCKLER, Johannes; LAZEGA, Emmanuel; HAMMER, Ingmar (ed.). **Knowledge and networks**. New York: Springer, 2017. p. 337-372.

CAPUK, Suat. ICT Integration models into Middle and High School Curriculum in the USA. **Procedia - Social and Behavioral Sciences**, v. 191, p. 1218-1224, 2015. DOI: http://doi.org/10.1016/j.sbspro.2015.04.409. Accessed on: March 10th, 2023.

CARVALHO, Tainá; KLEBER, Mendes Pereira Dias; RUSSO, Ana Lúcia Rodrigues Gama; BRAGA, Eduardo dos Santos Oliveira; SANTOS, Amanda Ribeiro dos; SANTOS, Taís Conceição dos; CHRISPINO, Álvaro. A contextualização no ensino CTS: uma análise das redes sociais. **Revista Brasileira de Ensino de Ciência e Tecnologia**, Ponta Grossa, v. 14, n. 1, 2021. DOI: https://doi.org/10.3895/rbect.v14n1.12594. Accessed on: March 10th, 2023.

CHIZZOTTI, Antonio. Humanismo, educação e tecnologia. **Revista e-Curriculum**, São Paulo, v. 18, n. 2, p. 489-500, 2020. Retrieved from: https://revistas.pucsp.br/curriculum/article/view/48167. Accessed on: March 10th, 2023.

COSTA, Benedita Marta Gomes; PEDRO, Edilson da Silva; MACEDO, Gorete Ribeiro de. Scientific collaboration in biotechnology: the case of the northeast region in Brazil. **Scientometrics**, v. 95, p. 571-592, 2013. DOI: https://doi.org/10.1007/s11192-012-0924-1. Accessed on: March 10th, 2023.

DIAS, Thiago Magela Rodrigues; MOITA, Gray Farias; DIAS, Patricia Mascarenhas. Um estudo sobre a rede de colaboração científica dos pesquisadores brasileiros com currículos cadastrados na Plataforma Lattes. **Em Questão**, Porto Alegre, v. 25, n. 1, p. 63-86, 2019. Retrieved from: https://www.seer.ufrgs.br/EmQuestao/article/view/81536. Accessed on: March 10th, 2023.

EVANGELISTA, Gislene Rangel; SALES, Shirlei Rezende. Desajustes contemporâneos: um levantamento bibliográfico sobre currículo e tecnologias digitais. **Revista e-Curriculum**, São Paulo, v. 14, n. 3, p. 1107-1129, 2016. Retrieved from: https://revistas.pucsp.br/index.php/curriculum/article/view/23095. Accessed on: March 10th, 2023.

EVERETT, Martin; BORGATTI, Stephen P. Ego network betweenness. **Social Networks**, v. 27, n. 1, p. 31-38, 2005. Retrieved from: https://www.sciencedirect.com/science/article/pii/S037887330400067X. Accessed on: March 10th, 2023.

FIORI, Raquel; GOI, Mara Elisângela Jappe. Revisão da literatura em ambiente virtual de aprendizagem no ensino básico com uso de plataformas digitais. **REnCiMa – Revista de Ensino de Ciências e Matemática**, São Paulo, v. 12, n. 3, p. 1-18, 2021. Retrieved from: http://portal.amelica.org/ameli/jatsRepo/509/5092220028/html/. Accessed on: March 10th, 2023.

FONTES, Daniel Trugillo Martins; RODRIGUES, André Machado. Science Education Collaboration Network: the case of the Cultural-Historical Activity Theory. **Science & Education**, v. 32, 2023a. DOI: https://doi.org/10.1007/s11191-023-00479-8. Accessed on: March 10th, 2023.

FONTES, Daniel Trugillo Martins; RODRIGUES, André Machado. Uma análise de rede para as pesquisas do tipo mapeamento em Ensino de Física. **Ensino e Tecnologia em Revista**, Londrina, v. 7, n. 1, p. 364-378, 2023b. DOI: https://doi.org/10.3895/etr.v7n1.16709. Accessed on: March 10th, 2023.

FONTES, Daniel Trugillo Martins; BUENO, Rafaela; GHURON, Érick; RODRIGUES, André Machado. Redes de coautoría en la investigación en educación en electromagnetismo. **Revista de Enseñanza de la Física**, v. 35, n. extra, p. 123–130, 2023. Retrieved from: https://revistas.unc.edu.ar/index.php/revistaEF/article/view/43286. Accessed on December 7th, 2023.

FONTES, Daniel Trugillo Martins; RODRIGUES, André Machado. Análise local, pensamento global: estrutura e dinâmica de relações colaborativas na pesquisa em Ensino de Ciências. **Investigações em Ensino de Ciências**, Porto Alegre, v. 29, n. 1, p. 427-455, 2024. DOI: https://doi.org/10.22600/1518-8795.ienci2024v29n1p427. Accessed on December 7th, 2023.

GAZDA, Emmanuel; QUANDT, Carlos Olavo. Colaboração interinstitucional em pesquisa no Brasil: tendências em artigos na área de gestão da inovação. **RAE-Eletrônica**, São Paulo, v. 9, n. 2, p. 1-27, 2010. DOI: https://doi.org/10.1590/s1676-56482010000200010. Accessed on December 7th, 2023.

GLÜCKLER, Johannes; LAZEGA, Emmanuel; HAMMER, Ingmar. Exploring the interaction of space and networks in the creation of knowledge: an introduction. *In*: GLÜCKLER, Johannes; LAZEGA, Emmanuel; HAMMER, Ingmar (ed.). **Knowledge and networks**. New York: Springer, 2017. p.1-21.

HAYASHI, Maria Cristina Piumbato Innocentini; FERREIRA JR., Amarilio; BITTAR, Marisa; HAYASHI, Carlos Roberto Massao; SILVA, Márcia Regina da. História da educação brasileira: a produção científica na biblioteca eletrônica SCIELO. **Educação & Sociedade**, Campinas, v. 29, p. 181-211, 2008. DOI: https://doi.org/10.1590/S0101-73302008000100010. Accessed on December 7th, 2023.

JAMIESON-PROCTOR, Romina M.; BURNETT, Paul C.; FINGER, Glenn; WATSON, Glenice. ICT integration and teachers' confidence in using ICT for teaching and learning in

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations

26

Queensland state schools. **Australasian Journal of Educational Technology**, v. 22, n. 4, p. 511-530, 2006. DOI: http://doi.org/10.14742/ajet.1283. Accessed on December 7th, 2023.

MATOS, Jainer Diogo Vieira; SILVA, José Roberto Cruz e; RIBEIRO, Altair Fábio Silvério; GOMES, Roberta Martins Mendonça; FERREIRA, Júlio César; MATOS, Fernando Barbosa. Aprendizagem significativa por meio do uso de TICs: levantamento das produções da área de ensino de 2016 a 2018. **RENOTE**, Porto Alegre, v. 17, n. 1, p. 466-475, 2019. Retrieved from: https://seer.ufrgs.br/renote/article/view/95855. Accessed on: March 10th, 2023.

MELO, Thiago Brañas de; PONTES, Ferrnanda Costa da Cruz de; ALBUQUERQUE, Marcia Bengio de; SILVA, Marco Aurélio Ferreira Brasil da; CHRISPINO, Álvaro. Research issues orbiting the STS Approach: a network analysis of the Brazilian academic production in Education. **Revista Brasileira de Pesquisa em Educação em Ciências**, Rio de Janeiro, v. 16, n. 3, p. 607-626, 2016. Retrieved from: https://periodicos.ufmg.br/index.php/rbpec/article/view/4584. Accessed on: March 10th, 2023.

MENA-CHALCO, Jesús Pascual; DIGIAMPIETRI, Luciano Antonio; LOPES, Fabrício Martins; CESAR JR., Roberto Marcondes. Brazilian bibliometric coauthorship networks. **Journal of the Association for Information Science and Technology**, v. 65, n. 7, p. 1424-1445, 2014. Retrieved from: https://asistdl.onlinelibrary.wiley.com/doi/abs/10.1002/asi.23010. Accessed on: March 10th, 2023.

MEZZADRI, André Luis; PEDROSO, Bruno; PILATTI, Luiz Alberto; PINTO, Guilherme Moreira Caetano; PICININ, Claudia Tania. Redes colaborativas brasileiras em qualidade de vida: análise cientométrica das publicações de 2000 a 2011. **Revista de Ensino, Ciência e Inovação em Saúde**, Petrolina, v. 2, n. 1, p. 88-100, 2021. DOI: https://doi.org/10.51909/recis.v2i1.97. Accessed on December 7th, 2023.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT. Supporting teachers' use of ICT in upper secondary classrooms during and after COVID-19 pandemic. **Teaching in Focus**, v. 41, p. 1-6, 2021. Retrieved from: https://www.oecd-ilibrary.org/docserver/5e5494ac-en.pdf?expires=1680913789&id=id&accname=guest&checksum=6EA61CE4494CFA29C7764A34CD2F7609. Accessed on: March 10th, 2023.

PAULA, Helder de Figueiredo. Fundamentos pedagógicos para o uso de simulações e laboratórios virtuais no ensino de ciências. **Revista Brasileira de Pesquisa em Educação em Ciências**, Rio de Janeiro, v. 17, n. 1, p. 75-103, 2017. DOI: https://doi.org/10.28976/1984-2686rbpec201717175. Retrieved from: https://periodicos.ufmg.br/index.php/rbpec/article/view/4476. Accessed on: March 10th, 2023.

PINAR, William Frederick. Introduction. *In*: PINAR, William Frederick (ed.). **International Handbook of Curriculum Research**. Londres: Lawrence Erlbaum Associates, 2003. p. 1-34.

POLONI, Maria José; SILVA, Neide Cristina. Educação de Jovens e Adultos: do direito à realidade. *In*: MONTEIRO, Solange Aparecida de Souza (ed.). **A educação em suas dimensões pedagógica, política, social e cultural**. Ponta Grossa: Atena, 2020. p. 113-126.

SANTIAGO, Arthur; MATTOS, Cristiano. From classroom education to remote emergency education: transformations in a dialogical pedagogy proposal. **Dialogic Pedagogy: An International Online Journal**, v. 11, n. 1, p. DT1–DT21, 2023. Retrieved from: https://dpj.pitt.edu/ojs/dpj1/article/view/462. Accessed on: March 10th, 2023.

SCHERER, Ronny; TEO, Timothy. Unpacking teachers' intentions to integrate technology: A meta-analysis. **Educational Research Review**, [*s. l.*], v. 27, p. 90-109, 2019. Retrieved from: https://www.sciencedirect.com/science/article/pii/S1747938X18303622. Accessed on: March 10th, 2023.

SCOTT, John. **What is social network analysis?** [*S. l.*]: Bloomsbury Academic, 2012.

SELWYN, Neil. The "new" connectivities of digital education. *In*: APPLE, Michael W.; BALL, Stephen J.; GANDIN, Luis Armando (ed.). **The Routledge International Handbook of the Sociology of Education**. New York: Taylor & Francis, 2010. p. 90-98.

SILVA, Tomaz Tadeu. **Documentos de identidade**: uma introdução às teorias do currículo. Belo Horizonte: Autêntica, 1999.

SIMÕES, Roberta Cristina Moreira; BRAGA, Eduardo dos Santos de Oliveira; RUSSO, Ana Lúcia Rodrigues Gama; RÔÇAS, Giselle. Produção nacional sobre metodologias ativas no ensino de Ciências: uma análise em rede nas revistas Qualis A1 da Área de Ensino. **Ensino e Tecnologia em Revista**, Londrina, v. 4, n. 2, p. 1-21, 2020. DOI: https://doi.org/10.3895/etr.v4n2.13034. Accessed on December 7th, 2023.

SOUZA, Cristina Gomes de; BARBASTEFANO, Rafael Garcia; LIMA, Leonardo Silva. Redes de colaboração científica na área de química no Brasil: um estudo baseado nas coautorias dos artigos da revista Química Nova. **Química Nova**, São Paulo, v. 35, p. 671-676, 2012. DOI: https://doi.org/10.1590/S0100-40422012000400003. Accessed on December 7th, 2023.

WASSERMAN, Stanley; FAUST, Katherine. **Social Network Analysis**: methods and applications. Cambridge: Cambridge University Press, 1994.

YAN, Erjia; DING, Ying. Applying centrality measures to impact analysis: A coauthorship network analysis. **Journal of the American Society for Information Science and Technology**, [*s. l.*], v. 60, n. 10, p. 2107-2118, 2009. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1002/asi.21128. Accessed on: March 10th, 2023.

YOUNG, Michael. Superando a crise na teoria do currículo: uma abordagem baseada no conhecimento. **Cadernos Cenpec**, v. 3, n. 2, p. 225-250, 2013. DOI: http://doi.org/10.18676/cadernoscenpec.v3i2.238. Accessed on December 7th, 2023.

Daniel Trugillo Martins Fontes, Esdras Viggiano, André Machado Rodrigues, Cristiano Mattos
Studying relationships of technology in curriculum research:
a network approach to connections and collaborations
28

ZHANG, Lei; ZHANG, Hui; WANG, Kai. Media Literacy Education and Curriculum Integration: A Literature Review. **International Journal of Contemporary Education**, v. 3, n. 1, p. 55-64, 2020. DOI: https://doi.org/10.11114/ijce.v3i1.4769. Accessed on December 7th, 2023.

ZERVAS, Panagiotis; TSITMIDELLI, Asimenia; SAMPSON, Demetrios G.; CHEN, Nian-Shing; KINSHUK. Studying research collaboration patterns via coauthorship analysis in the field of TeL: the case of educational technology & society journal. **Journal of Educational Technology & Society**, v. 17, n. 4, p. 1-16, 2014. Retrieved from: https://www.jstor.org/stable/pdf/jeductechsoci.17.4.1.pdf. Accessed on: March 10th, 2023.

NOTES:

[1] In Portuguese, the translated thematic issue is "Currículo e tecnologias: redes, territórios e diversidades".

[2] Data are available from the corresponding author, upon reasonable request.

[3] Lattes platform hosts the Lattes curriculum which is ubiquitous within Brazilian academic life, and it is a reliable database to recover academic data from Brazilian scholars.

[4] The level of agreement was 97%, with a substantial kappa of 0.79 and a p-value < 0.01.

[5] The ten translated keywords from the Table 1 corresponds to 'currículo', 'TIC', 'professores', 'aprendizagem', 'Paulo Freire', 'avaliação', 'educação', 'legislação', 'formação de professores', 'culturas', respectively.

[6] Only one author published more than one ICT-CR paper with two different affiliations (as a doctoral student and later as a college professor). In this particular case, we included this author in the category of college professors or PhD scholars (red node in Figure 5).