The use of social network analysis in educational sciences studies

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Highlights	Abstract
• This research emphasizes social network analysis studies in the field of educational sciences has shown a growing trend in recent years. • The foundational models, theories, and concepts of the study were examined and grouped into six themes: social paradigm, learning environments/tools, learning approaches/methods, feedback/evaluation, informal approaches in teaching, and individual characteristics. • The article shows a significant preference for quantitative research and mixed research paradigms over the qualitative research paradigm. • This research offers suggestions for the use of SNA in Educational sciences.	Since social networks analysis in education offers valuable insights into social structures and social dynamics that shapes individuals behaviors and information storage and transmission, it has become a hot topic in educational science studies. The aim of this study is to examine the educational sciences studies conducted at higher education level in which social network analysis is used. The studies were analyzed based on journals, years, author countries, number of citations, models, theories, and concepts, research methods and target audience. Content analysis method was used in the study. The reliability of inter-coder agreement was calculated as .88. The findings were categorized under certain themes according to the research questions. According to the results, Internet and Higher Education (n=6) and Computers and Education (n=5) were the journals with the most publications, while 2019 was the year that the most studies (n=12) were conducted. The studies were mostly conducted by authors in the USA. "Seeing' the learning community: An exploration of the development of a resource for monitoring online student networking" was the most cited article. When the underlying models, theories and concepts in the studies were analyzed, six themes emerged: social paradigm, learning environments/tools, learning approaches/methods, feedback/assessment, informal approaches to teaching and individual characteristics. The most frequently used method was quantitative research, and the target group was undergraduate students. The target group size was mostly between 30-60, and convenience sampling was primarily employed for the target group selection. According to the findings and results of the study, suggestions for the use of social network analysis in the field of educational sciences were presented.
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1. Introduction

Currently, numerous aspects of life, events, and processes are intricately intertwined within interconnected systems. These systems are commonly referred to as social networks (Scott, 2000). A social network comprises social entities, like individuals, groups, and organizations, with various types of interactions or relationships among them (Tabassum et al., 2018). For instance, students in a classroom create a social

network, just like individuals who interact through online platforms. This highlights the fact that social networks are not solely limited to people communicating on digital platforms like Facebook, LinkedIn, or other online platforms. They can emerge in various contexts, including face-to-face interactions within educational environments (Somyürek & Güyer, 2020). The relations in these social networks can range from professional to personal, from simple to complex, and can be portrayed as network graphs with features like relationship, interaction, and similarity. The method of investigating these relationships within social networks is known as social network analysis.

Social network analysis concentrates on the actors within the networks and their interconnections, offering insights into the networks and their members. The foundational premise of social network analysis is that individuals' interconnectedness impacts behavior (McGloin, & Kirk, 2014). So, unlike traditional methods, this approach is grounded in the idea that relationships are crucial (Freeman, 2006) and focuses on gathering more data about relationships, which are sourced from social networks. Social network analysis aims to comprehend the factors that either facilitate or obstruct information flow between related structures (Wasserman & Faust, 1994).

The roots of SNA can be traced back to the 1930s. It has been employed to investigate social interactions across diverse fields, including health, communication, economics, political science, and engineering (Carolan, 2014). SNA has also gained prominence in educational science studies. Social network analysis is crucial to comprehend the interplay between student network creation and its impact on students. In educational research, the network structure is studied to discern how social networks affect learning outcomes. For instance, the effectiveness of a pedagogical method or technique could be linked to the network structure developed during the learning process. SNA can shed light on such connections. As per Bruun and Brewe (2013), a student's standing within communication and interaction networks ties in with their performance. SNA is utilized to explore the link between student performance and interactions. Also, Cela, Sicilia and Sanchez (2015) employed SNA to probe the pedagogical dynamics of group structures and communities in e-learning. Given the importance of "big data" stored in learning management systems, SNA is increasingly applied in the realm of online higher education (Jan, Vlachopoulos & Parsell, 2019). Moreover, SNA can offer fresh perspectives for researchers keen on altering higher education curricula, introducing new teaching methods, promoting fairness in student interactions, or enhancing links between classrooms and communities (Grunspan Wiggins, & Goodreau, 2014).

SNA provides a host of tools for investigating fundamental concepts in the learning process. It highlights its relations with concepts like learning relationship, interaction, communities of practice, collaborative learning, and learning communities (McLaughlin & Talbert, 2006; Bruun & Brewe, 2013; Gewerc et al., 2014; Ellis, Han & Pardo., 2019; Froehlich et al., 2020).

Systematic review studies play a crucial role in promoting a deeper understanding of various topics by providing a comprehensive and unbiased summary of all available evidence. However, there are no review studies within the scope of SNA that aims to identify the overarching trend in the field of educational sciences at the higher education level. Thus, the primary objective of this study is to address and bridge this existing knowledge gap.

Aim of Study

The aim of this study is to examine the educational sciences studies conducted at higher education level in which social network analysis is used by content analysis method.

In line with this general purpose, the following questions were sought to be answered.

In the studies on social network analysis conducted at higher education level

- What is the distribution according to journals, years, authors' countries, number of citations?
- What are the underlying models, theories and concepts?
- What are the underlying research paradigms?
- What is the target audience, what is the size of the target audience, how was the target audience selected, what are the characteristics of the target audience?

2. Methodology

This study utilized the content analysis method. Content analysis is described as the process of collecting research from a specific field according to certain objectives, consolidating them around a shared focal point, categorizing them based on their similar features, and forming a systematic entity (Cohen, Manion, & Morrison, 2007). Depending on the study's goals, content analysis methods can be divided into descriptive content analysis, thematic content analysis, and meta-analysis (Çalık & Sözbilir, 2014). This research employed descriptive content analysis from among the content analysis methods. Descriptive content analysis is a systematic review study aiming to identify prevailing trends in a specific research area. General trends are attempted to be determined using descriptive content analysis, with frequency and percentage-level statistics (Dinçer, 2018).

The content analysis process is a systematic procedure that involves certain stages (Büyüköztürk et al., 2015). Defining the objective, determining the research and selection criteria, coding, data analysis, and reporting are the steps that guide the research process. Within the context of this study, the steps of descriptive content analysis are outlined below.

The objective of this study is to determine the general trend in studies using social network analysis conducted at the higher education level within the field of educational sciences. The study includes articles screened in journals in the Web of Science database between 2010-2020. The search process used the keywords "Social Network Analysis, SNA and Higher Education."

The following inclusion and exclusion criteria were determined in the selection of the relevant articles:

- Published between 2010-2020
- Published in a journal indexed in the Web of Science database
- A peer-reviewed journal
- English language
- Related to the field of Educational Sciences
- Includes higher education level
- Review studies were excluded from the scope of the research.

Finally, the data was coded and reported in tables consisting of frequencies and percentages.

The study employed a data collection tool consisting of research questions developed by the researcher and was evaluated by an academic expert with a PhD in educational technologies. The final form of the data collection tool included the article's title, the publishing journal, the publication year, the authors' countries, the total citation count, the models, theories, and concepts used, research paradigms, the target group, size of the target group, selection of the target group, and characteristics of the target group.

To achieve the aim of research, a search was conducted in the Web of Science database using specific keywords in the subject field. The keywords included terms related to educational levels such as "higher education", "post-secondary education", "third-level", "tertiary education", "graduate", "undergraduate", and "post-graduate", in combination with "Social Network Analysis" and its abbreviation "SNA". The search query was formulated as follows: ("social network analysis" or SNA) and ("higher education" or "post-secondary education" or "third-level" or "tertiary education" or graduate or undergraduate or "post-graduate" or postgraduate). The keyword search in the Web of Science database yielded a total of 141 articles. Once the sub-field of educational sciences was chosen, 94 articles remained. Following the application of the inclusion and exclusion criteria, the total number of articles included in the study was set at 75.

The reliability of the study was established in two phases. The first stage involved determining whether the articles were suitable for inclusion in the research process, while the second stage concerned the

appropriateness of the data regarding the coding process. In the first stage, two researchers read the abstracts of the articles, coding articles suitable for the research's scope as 1, and unsuitable articles as 0. The Cohen Kappa was employed to measure the agreement between the two researchers. The resulting Kappa coefficient, at 0.81, indicated an excellent level of agreement between the two researchers. In the second stage, another researcher with a PhD in Educational Technologies analyzed 8 (10 percent) of the articles included in the study. In order to verify the reliability of the codes and themes, the agreement between the two researchers was analyzed. Miles and Huberman's formula was used to calculate the agreement between the two researchers. Inter-rater agreement is the most fundamental approach to ensuring reliability (Moskal & Leydens, 2000). As per Miles and Huberman (1994), reliability can be computed by dividing the number of agreements by the total number of agreements plus disagreements. The reliability percentage for the coding results was found to be 0.88. The coders reviewed the disagreements to reach the most appropriate conclusion.

3. Findings

The analyzed studies are presented in terms of the publishing journals, publication year, countries of the authors, citation counts, models, theories, concepts used, research paradigms, target groups, sizes of target groups, selection of target groups, and characteristics of target groups.

3.1. Distribution by Journals

Table 1 indicates the number of publications by journals. The top three journals are Internet and Higher Education (n=6), Computers and Education (n=5), and British Journal of Educational Technology (n=4). Following them are Education Technology Research Development (ETR&D) and Journal of Computer Assisted Learning, each with three articles. Two articles were published in 14 journals. The total count for the remaining journals is 26 (n=26).

Table 1.

Distribution by Journals

Journal	f
Internet and Higher Education	6
Computers and Education	5
British Journal of Educational Technology (BJET)	4
Education Technology Research Development (ETR&D)	3
Journal of Computer-Assisted Learning	3
Australasian Journal of Educational Technology	2
Educational Technology & Society	2
Higher Education	2
IEEE Transactions on Learning Technologies	2
Innovative Higher Education	2
Interactive Learning Environments	2
International Journal of Science Education	2
Journal of Educational Computing Research	2
Journal of Studies in International Education	2
Journal of the Learning Sciences	2
Online Learning	2
Studies in Higher Education	2
Technology, Knowledge and Learning	2
Journal of the Learning Sciences	2
Other	26
Total	**75**

3.2. *Distribution by Year*

When the studies are analyzed year-by-year, it is observed that the highest number of studies (n=12) were conducted in 2019. Following 2019, the year with the most studies is 2018, with a total of 11 articles. Ten articles were published in both 2014 and 2016, six articles in 2015 and 2017, five articles in 2013, three in 2010, two in 2012, and one in 2011. The number of articles published in 2020 is nine. The relatively low count for 2020 is likely due to the last date for journal scanning being in May 2020. Based on these findings, it can be inferred that interest in social network analysis studies in the field of educational sciences has shown a growing trend in recent years.

Distribution by Year

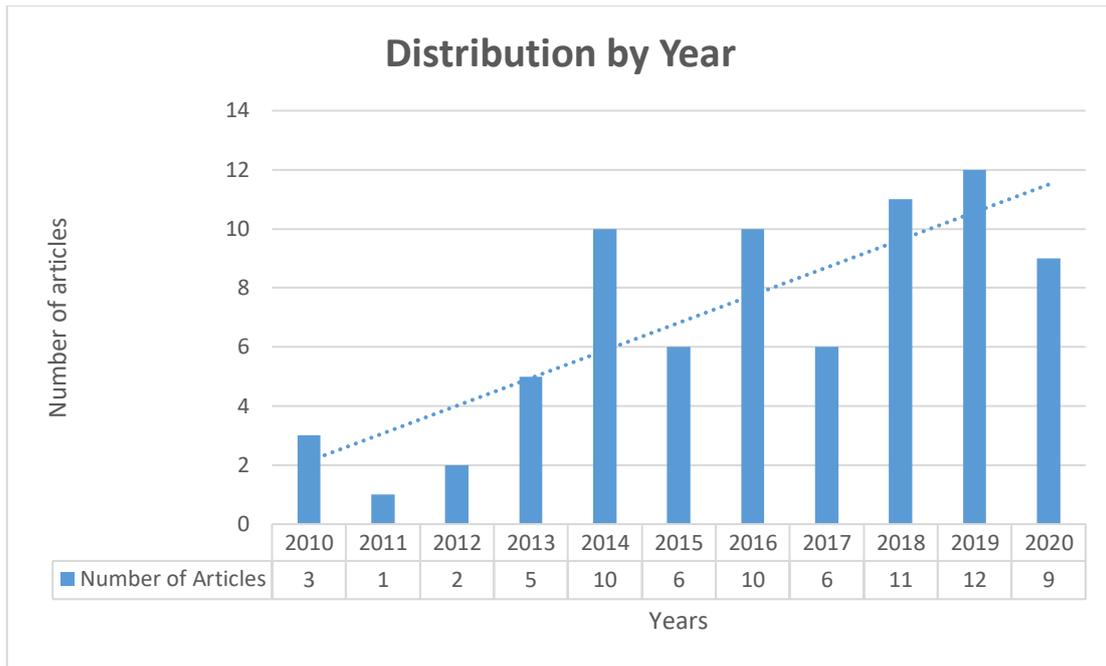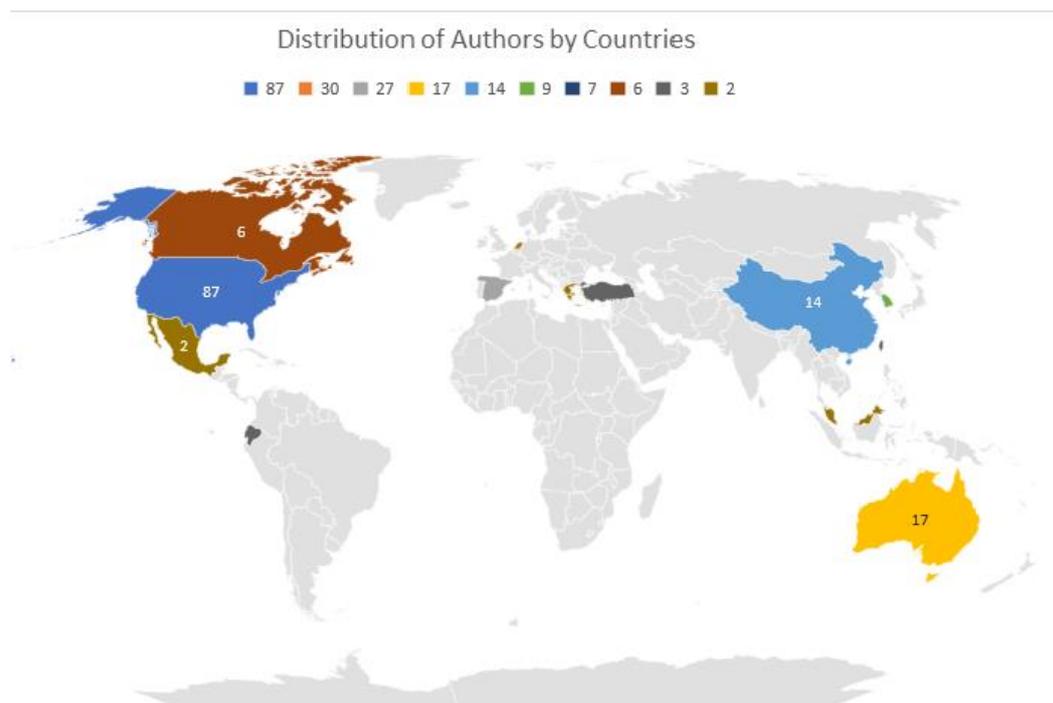|	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number of Articles	3	1	2	5	10	6	10	6	11	12	9

Figure 1. Distribution by Year

3.3. *Distribution of Authors by Country*

The distribution of publications, segmented by country, is represented in Figure 2. The total count in the distribution by countries surpasses the number of analyzed articles in the study, as multiple researchers contribute to a single article.

Figure 2. Distribution of Authors by Country

In total, researchers from 19 different countries participated in the 75 studies. The majority of studies employing social network analysis in higher education are carried out by authors from the USA (n=87), followed by the UK and Spain, with 30 and 27 researchers respectively. Other significant contributors include Australia with 17 researchers, the People's Republic of China with 14, South Korea with 9, Hong Kong with 7, and Canada with 6. Countries with three contributing authors within the research scope include Ecuador, Taiwan, and Turkey. The Netherlands, Malaysia, Mexico, Singapore, and Greece each have two contributing authors. Under the "other" category in the graph, it's observed that three authors are researchers from Germany, Belgium, and Tanzania.

3.4. *Distribution by Number of Citations*

The overall citation numbers in Google Scholar and Web of Science were used to find the citation numbers for the publications included in the study.

The citation counts of the articles within the scope of the study were assessed via Google Scholar, and the top 20 most cited articles were listed. Dawson's 2010 article in the British Journal of Educational Technology (BJET), "Seeing' the learning community: An exploration of the development of a resource for monitoring online student networking," is the most cited article with 246 citations. Gillani and Eynon's (2014) "Communication patterns in massively open online courses" published in Internet and Higher Education stands as the second most cited article with 242 citations. The average citation count for the top 20 articles is 95.4, and 21 articles have received more than 40 citations.

The citation counts of the articles within the study scope were also analyzed on Web of Science (WoS), and the 20 most cited articles were listed. Upon analysis of citation numbers on WoS, similar to Google Scholar, the same publication holds the top spot (f= 86). The second most cited article was also the same with 83 citations. The average citation count for the first 20 articles was calculated as 36.85. Fifteen articles have received more than 20 citations. As expected, the citation numbers in the Web of Science database are lower than those in Google Scholar.

3.5. *Underlying Models, Theories, and Concepts*

The data was gathered and systematically coded to identify patterns. Through this coding, similarities were found, leading to the creation of six distinct themes based on these shared characteristics. The foundational models, theories, and concepts of the study were examined and grouped into six themes: social paradigm, learning environments/tools, learning approaches/methods, feedback/evaluation, informal approaches in teaching, and individual characteristics. The social paradigm topped the list among the models, theories, and concepts foundational to the analyzed studies (f=66), approximately 43%. Thirteen categories are included in the social paradigm dimension: collaborative learning, community of practice, learning communities, social interaction/interaction, social capital theory, community of inquiry, social learning, social identity theory, cognitive presence, social presence, teaching presence, and social network theory.

Following the social paradigm, the most frequent theme is learning environments/tools. This theme, appearing in 44 studies, corresponds to a total of 28.57%. This theme includes categories as asynchronous online discussions/group discussions, blended learning, online learning, personal learning environments (PLE), learning analytics, distributed learning, e-learning, multi-user virtual environments (MUVE), massive open online courses (MOOC), open education resources, educational big data, and multimedia digital objects.

Another theme is learning approaches/methods. This theme includes participatory learning, knowledge building/knowledge diffusion, active learning, creativity, problem-based learning, situational learning, reflective thinking, self-regulated learning, peer guidance, evidence-based learning, critical thinking, collaborative regulation, self-efficacy (Social Cognitive Career Theory), and constructivist learning categories. This theme was featured in 29 studies (18.83%). In this theme, the sub-category of participatory learning, which includes concepts like participation, participatory learning, participatory learning roles, participation theory, and cognitive participation, stands out. These concepts were included in six studies, corresponding to 3.90%.

The theme of feedback/assessment comprises peer/collaborative assessment (f=2) and feedback (f=2). The theme of informal approaches in teaching includes three categories: lifelong learning (f=1), instructional sustainability (f=1), and informal learning (f=1). The individual characteristics theme includes the categories of cultural characteristics (f=2) and learning styles (f=1). Five concepts and theories were categorized under a separate theme called other. These concepts are communication, democratic education, technological pedagogical content knowledge, instructional design knowledge, and faculty development programs. Given the possibility that a given study may focus on multiple models, theories or concepts, 154 codes were acquired under this heading.

Table 2.
Underlying models, theories and concepts

Theme	Models, Theories or Concepts	f	%
	Collaborative learning	16	10.39%
	Social interaction/online interaction/interaction	10	6.49%
	Community of practice	9	5.84%
	Learning communities	6	3.90%
Social paradigm	Community of inquiry	5	3.25%
	Social capital theory	4	2.60%
	Social learning	3	1.95%
	Social identity theory	3	1.95%
	Cognitive presence	3	1.95%
	Social presence	3	1.95%

	Teaching presence	2	1.30%
	Social network theory	2	1.30%
	Total	**66**	**42.86%**
Learning settings / tools	Asynchronous online discussions/ Group discussions	13	8.44%
	Blended learning	7	4.55%
	Online learning	6	3.90%
	Personal learning environments (PLE)	3	1.95%
	Learning analytics	3	1.95%
	E learning	3	1.95%
	Distributed learning	2	1.30%
	Multi-User Virtual Environments (MUVE)	2	1.30%
	Open educational resources	2	1.30%
	Educational big data	1	0.65%
	MOOC	1	0.65%
	Multimedia digital objects	1	0.65%
	Total	**44**	**28.57%**
Learning approaches / methods	Participatory learning	6	3.90%
	Knowledge building and knowledge diffusion	5	3.25%
	Active learning	2	1.30%
	Creativity	2	1.30%
	Self-regulated learning	2	1.30%
	Peer mentoring	2	1.30%
	Evidence-based learning	2	1.30%
	Problem-based learning	1	0.65%
	Situational learning	1	0.65%
	Reflective thinking	1	0.65%
	Self-regulated learning	1	0.65%
	Critical thinking	1	0.65%
	Co regulation	1	0.65%
	Self-efficacy (Social Cognitive Career Theory)	1	0.65%
	Constructivist learning	1	0.65%
	Total	**29**	**18.83%**
Feedback / Assessment	Peer Assessment / Collaborative Assessment	2	1.30%
	Feedback	2	1.30%
	Total	**4**	**2.60%**
Informal approaches in teaching	Lifelong learning	1	0.65%
	Sustainability in teaching	1	0.65%
	Informal learning	1	0.65%
	Total	**3**	**1.95%**
Individual characteristics	Cultural characteristics	2	1.30%
	Learning styles	1	0.65%
	Total	**3**	**1.95%**
Other		**5**	**3.25%**
	Total	**154**	**100%**

3.6. *Research Paradigms*

Upon analysis of the Table 3, it's observed that 40 of the studies were conducted within the quantitative research paradigm, 31 within the mixed research paradigm, and 4 within the qualitative research paradigm.

This shows notable preference for quantitative research and mixed research paradigms over the qualitative research paradigm.

Table 3.

Research Paradigms

Research Paradigm	f	%
Quantitative	40	53.33%
Mixed	31	41.33%
Qualitative	4	5.33%
Total	**75**	**100.00%**

3.7. *Target Group*

Table 4 reveals that the most frequently studied target group is undergraduate students (f=47), accounting for roughly 63 percent of all studies. Following undergraduate students, graduate students form the sample in the majority of the studies (f=14). They are succeeded by researchers/educators (f=6), instructors (f=4), and undergraduate students (graduate) (f=3). The target group that was least studied is teachers, with only one study.

Table 4.

Target group

Target group	f	%
Undergraduate students (Ongoing)	47	62.67%
Graduate students	14	18.67%
Researchers / Educators	6	8.00%
Teaching staff	4	5.33%
Undergraduate students (Graduate)	3	4.00%
Teachers	1	1.33%
Total	**75**	**100%**

3.7.1. *Target Group Characteristics*

Upon examining the Table 5, it's apparent that pre-service teachers are the most common subset within undergraduate students (f=10). Following pre-service teachers, engineering, computer sciences, and computer systems students form the target audience in five studies. Medical faculty and medical department students also make up the target audience in three studies. Other groups among undergraduate students each constitute the sample in a single study. There's one study where teachers form the target audience.

Upon analyzing the articles, and four studies where teaching staff form the target audience. The target group of teachers was identified as the K-12 teacher group. In the first of three studies involving instructors, the target audience consisted of instructors in Mathematics, Physics, Chemistry, Biology, and Geology; in the second study, instructors from Business Administration, Engineering, Tourism and Hotel Management, Mathematics, Psychology, and Biosciences were the target audience; and in the third study, the target audience consisted of instructors from the Biology and Chemistry departments. Undergraduate students in the student group were included in three studies.

Table 5.

Target Group Characteristics

Theme	Target Group Characteristics	f	%
	Undergraduate and Graduate Students	64	81.33
	• Teacher candidates	10	13.33
	• Engineering, computer science, computer systems students	5	6.67
	• Medical faculty, Medical department students	3	4.00
	• Social Education and Work students	1	0.13
	• Physics department students	1	0.13
	• Chemistry department students	1	0.13
	• Social and Education Policy students	1	0.13
	• Graduate students in learning sciences	1	0.13
	• Economics department students	1	0.13
	• Fine arts students	1	0.13
	• Biology department students	1	0.13
Students	• Psychology department students	1	0.13
	• Language department students	1	0.13
	• Public administration students	1	0.13
	• Students of Management and Politics, Women's Rights	1	0.13
	• Psychology, Medicine, Biochemistry, Economics, Management and Journalism students	1	0.13
	• Adult graduate students participating in professional development	1	0.13
	• Industrial Design Engineers and Business Management students	1	0.13
	• STEM departments	1	0.13
	• Graduate students doing engineering	1	0.13
	• Unspecified	26	34.67
	Sub-total	64	85.33
Researchers/Educators	Researchers	6	8
	Sub-total	6	8
	Mathematics, Physics, Chemistry, Biology and Geology	1	0.13
	Business, Engineering, Tourism and Hospitality, Mathematics, Psychology and Biosciences	1	0.13
Teaching Staff	Biology and Chemistry departments	1	0.13
	Unspecified	1	0.13
	Sub-total	4	5.33
Teachers	K-12 teachers	1	0.13
	Sub-total	1	0.13
Total		**75**	**100.00**

3.7.2. Sample Size

It was found that the sample size in the studies ranged from 3 to 4337. As it can be seen in Table 12, the largest sample size falls within the range of 31-60, accounting for 24% (f=18) of studies. This is followed by a sample size range of 1-30, making up 17.33 percent (f=13) of the studies. These sample sizes are followed by 101-150 (f=12) and 201-300 (f=11), respectively. The sample size range that features in the fewest studies is over 1000 and 151-200 (f=3). In one study, the sample size was not specified. Furthermore, in eight studies, different cases were analyzed and, therefore, more than one sample was included in the

study. In seven studies, two different samples were analyzed, while in one study, seven different samples were analyzed.
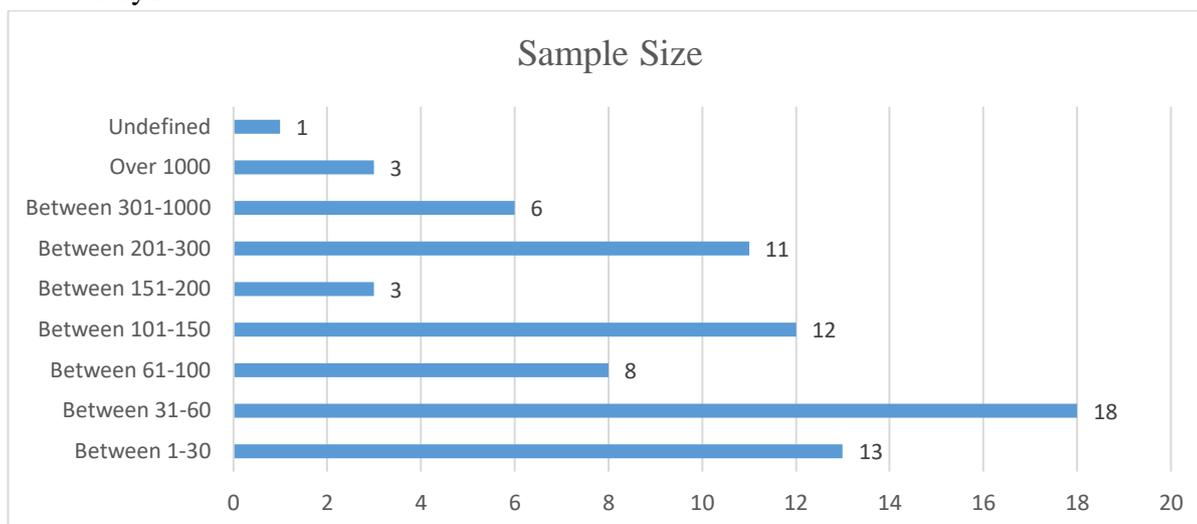

Figure 3. Sample Size

3.7.3. *Target Group Selection*

It's observed that the convenience sampling method was the most frequently employed in the studies (f=67), making up 89% of all the analyzed studies. Purposive sampling was chosen in seven articles. The systematic sample selection method was utilized in one study.

Table 6.

Target Group Selection

Target Group Selection	f	%
Convenience sampling	67	89.3
Purposive sampling	7	9.3
Systematic sample	1	1.3
Total	**75**	**100**

4. Conclusion and Discussion

This study examined 75 educational sciences studies conducted at the higher education level, utilizing social network analysis and published between 2010 and 2020 in the Web of Science database. The analysis focused on various aspects of these studies, including the publishing journals, publication years, countries of the authors, citation counts, models, theories, and concepts employed. Additionally, the research paradigms, target groups, sizes of target groups, selection criteria for target groups, and characteristics of these target groups were also investigated.

According to the results of content analysis, the majority of articles were published in the journal, Internet and Higher Education (f=6). This journal, published quarterly, is specifically focused on contemporary issues and future developments related to online learning-teaching and management in higher education. Given its scope, which directly aligns with the keywords used in the content analysis such as "higher education," "post-secondary education," "graduate," "undergraduate," and its focus on online learning-teaching, it comes as no surprise that many studies found a suitable platform for publication in this journal.C&E and BJET are seen as important journals in the field of educational technology. In addition, C&E journal is published between 12-17 times a year and BJET is published 12 times a year. This frequent

publication schedule, combined with their reputable status in the field, likely contributed to their prominence within the scope of this content analysis. Biancani and McFarland (2013), in their study examining social network analysis in higher education, stated that the articles were mostly published in journals in the field of informatics. In this content analysis study, unlike Biancani and McFarland (2013), since social network analysis studies in the field of education were examined, it is not surprising that the journals in the field of educational technology, where information technologies are studied in educational sciences, are predominant, rather than directly in the field of Informatics.

It is known that the history of social network analysis studies dates back to the 1930s. In recent years, social network analysis (SNA) has evolved from a specialized method used in a small part of social sciences to a popular approach applied to research questions in social sciences. In line with the findings obtained in the study, it can be said that between 2010 and 2020, although the number of publications decreased in some years, there was an upward trend in general. It was observed that the year with the highest number of publications among the years examined was 2019 and the year with the lowest number of publications was 2011. The fact that the number of publications reached in 2020 was 9 and this number was lower than the previous year is due to the fact that the articles were last scanned in May 2020. Similar to this result, Biancani and McFarland (2013), in their study examining social network analysis studies in higher education, determined that there was a regular and significant increase from the early 2000s to 2012. It is thought that there are various reasons for the increasing trend in the number of publications over the years. As it is known, digital and mobile technologies and easily accessible social media applications have become an indispensable part of daily life for people all over the world in recent years. According to the We are Social (2020) report, more than 4.5 billion people in the world use the internet, while the number of social media users has exceeded 3.8 billion. The rise in the number of social network analysis studies can be attributed to two primary factors. Firstly, the collection of vast amounts of user data from social media applications and other big data environments, such as Massive Open Online Courses and Online Streaming Platforms, has contributed significantly. Researchers aim to extract meaningful insights by analyzing this extensive data. Additionally, the increasing availability and support of comprehensive and user-friendly statistical tools/software, as noted by Moolenear in 2012, have played a crucial role in fostering more social network analysis studies. The upward trend in the number of publications analyzed indicates an increasing interest in social network analysis in the field of educational sciences. This demonstrates the growing recognition of the value and relevance of this research approach.

When the distribution of authors by country was analyzed, it became evident that 75 studies involved researchers from 19 different countries. Among these 19 countries, it was determined that researchers working at universities in the USA constitute the majority. The fact that the U.S.A. is quite high in terms of author distribution compared to other countries may be due to the fact that the native language of the country is English and the number of universities and research institutions in the country. In addition, the high number of US scientists in the articles with more than 4 authors is noteworthy. In 16 of the analyzed articles, the number of authors varies between 4 and 10. Among these 16 articles, it was observed that the authors of 7 articles consisted only of U.S. scientists, and in 2 articles, U.S. scientists collaborated with scientists from the People's Republic of China. In light of these results, it can be said that U.S. scientists collaborate more and take part in multi-authored studies. The fact that U.S. scientists are more involved in multi-authored studies can also be considered as a factor in the fact that the U.S. ranks first.

According to Google Scholar and Web of Science data, the article "Seeing' the learning community: An exploration of the development of a resource for monitoring online student networking" by Dawson published in BJET in 2010 has the most citations. This article aimed to identify the differences between the individual networks of high and low performing students in an online learning environment. The study's

notable strengths lie in its extensive sample size, encompassing a large number of participants, and the meticulous extraction of accurate and reliable data through social network data mining. This data was subsequently subjected to thorough analysis using social network analysis, further enhancing the study's robustness and credibility. In addition, the study's publication in 2010, within a high-impact factor journal like BJET, adds to its credibility and potential for influence. The study's multifaceted approach, incorporating tool development and in-depth examination of network structures and relationships based on the data obtained, is believed to contribute significantly to its citation count. The comprehensive nature of the research and its detailed analysis likely contribute to its wider recognition and citation within the academic community.

The models, theories and concepts based on the studies were examined and specific themes were derived. The six themes emerged, namely: social paradigm, learning environments/tools, learning approaches/methods, feedback/evaluation, informal approaches in teaching, and individual characteristics. Among the identified themes, the social paradigm theme stands out with the largest number of studies conducted. This theme encompasses 13 categories including collaborative learning, communities of practice, learning communities, social interaction/interaction, social capital theory, communities of inquiry, social learning, social identity theory, cognitive presence, social presence, teaching presence, and social network theory. The most common concept in the articles related to the social paradigm theme is collaborative learning. Collaborative learning is based on the idea that learning is a social act in which students communicate and interact among themselves (Gerlach, 1994). In research, social network analysis has been used to analyze the intensity of student contributions in collaborative environments (Gewerc, Montero, & Lama, 2014), to reveal the quality of collaborative learning experiences and collaborative learning models (Ellis, Han, & Pardo, 2019), to determine the contribution of collaborative learning to knowledge creation and social interaction (Sun et al., 2018), and to understand students' discussion patterns and collaboration processes using social collaboration tools (Chan & Pow, 2020). Studies on community building also have an important place in the social paradigm theme. Groups that socially construct knowledge in a particular field are referred to as communities of practice, inquiry/research and learning communities in the literature.

Among the themes encompassing the models, theories, and concepts of studies, the second most frequently explored theme was learning environments and tools. This theme encapsulates categories such as asynchronous online discussions/group discussions, blended learning, online learning, personal learning environments (PLE), learning analytics, e-learning, distributed learning, multi-user virtual environments (MUVE), massive open online courses (MOOCs), open educational resources, educational big data, and multimedia digital objects. It appears that asynchronous online discussions are the most common concept within the learning environments/tools theme. As a popular instrument, asynchronous online discussions are frequently employed to exchanges ideas and perspectives and to facilitate interactions among learners (Hew, Cheung, & Ng, 2010). Participants who communicate and work together through asynchronous online discussions constitute a critical segment of a virtual community. Asynchronous online discussions serve as a crucial instrument in digital courses by fostering knowledge sharing, idea exchange, and mentorship (Liu, Magjuka, Bonk, & Lee, 2007). The large amount of data generated in online discussions is very useful for instructors. Through the analysis of this data, it becomes feasible to monitor the learning progress of students, enabling timely interventions to bolster their performance and ensure successful completion of online courses (Kim, Park, Yoon, & Jo, 2016). Additionally, online discussions aid in the cultivation of advanced cognitive skills and the adaptation and application of knowledge to novel situations (Wu & Hiltz, 2004). The extensive benefits of online discussions for the learning process, along with the ease of gathering substantial data in online discussion settings, and the possibility of analyzing this data

through social network analysis, likely account for the considerable number of studies focused on this concept.

Among the themes related to the models, theories, and concepts, the third most common theme was learning approaches or methods. Participatory learning, knowledge building and knowledge diffusion, active learning, creativity, peer mentoring, evidence-based learning, problem-based learning, situational learning, reflective thinking, self-regulated learning, critical thinking, collaborative regulation, self-efficacy, constructivist learning are learning approaches/methods in this theme. These learning approaches and methods provide a broad framework explaining the mechanism of learning, the factors influencing it, and the ideal characteristics of a learning environment. Moreover, these methods and approaches help clarify the essential factors that influence the extent of learning and the interconnectedness among these variables (Senemoğlu, 2005). Throughout the reviewed studies, a consistent finding emerged, highlighting the crucial role of a specific learning approach and/or method in guiding instructional design and implementation. Subsequently, participant interactions related to this approach were analyzed using social network analysis. For instance, Alonso, Manrique, Martinez, and Vines (2015) employed social network analysis to examine how social relationships facilitate knowledge construction within a constructivist learning model. Among the various learning approaches and methods, participatory learning emerged as the most frequently studied theme. Participatory learning is closely linked to concepts such as social engagement, participatory learning, participatory learning roles, engagement theory, cognitive engagement.

Another significant category that emerges from the theme of learning approaches and methods is knowledge building and knowledge diffusion. Knowledge building is the process of developing new cognitive structures through shared objectives, group discussions, and idea synthesis. Social network analysis allows to visualize and understand the relationships that can either facilitate or impede knowledge building and sharing (Cross, Parker & Bargetti, 2002). One of the categories in the learning approaches/methods theme is peer mentoring. One of the most important contributions of social network analysis for educational researchers is the ability to reveal the peer impact (Carolan, 2014). Students are given leadership roles in peer-guided discussions by asking questions, generating answers, and providing feedback, and they are given the ability to direct the subject of discussion. These activities enhance students' commitment to the class and learning while also promoting knowledge formation (Hew & Cheung, 2011). Peer mentoring roles can provide vital possibilities for individuals to take on responsibility and engage in activities. Because it focuses on understanding the structure of peer interactions and relationships, social network analysis is appropriate for studying peer mentoring sites. Information on the ties that students make, in particular, is useful for demonstrating who talks to whom for support, how information moves among participants in peer mentoring settings, and patterns of interaction.

The studies were analyzed according to research paradigms and it was seen that quantitative studies were more numerous. Social network analysis inherently involves the application of mathematical and statistical techniques, making it natural for quantitative research to dominate the field. In the studies analyzed, mixed methods research emerges as the second most commonly used approach, following quantitative research. Mixed methods research tries to use multiple approaches while seeking answers to research questions by expanding the options of the researcher (Baki & Gökçek, 2012). Social network analysis is a highly effective tool for identifying interaction patterns, with a primary focus on quantitative aspects of the analysis. However, in research, solely relying on statistical and mathematical explanations may not always suffice. For instance, in an online learning environment, quantitative data such as the frequency and length of user posts, as well as response patterns, hold significance. Nevertheless, a more accurate interpretation of the data necessitates content analysis to examine the actual content of these posts. Content analysis enables researchers to draw more detailed conclusions about the nature of interactions. While social

network analysis provides valuable insights into the structure and value of interactions, the quality of interactions can be better assessed through content analysis (Gunawardena, Lowe, & Anderson, 1997). In addition, mixed methods can be employed to comprehensively analyze all the data within the network and complement it through triangulation. Mixed methods research has proven valuable in shedding light on the structures revealed by social network analysis (SNA) visualizations and conducting in-depth examinations of participant interactions (Morgan, 1998). This increases the value of the mixed paradigm in social network analysis studies. For example, Heo, Lim, and Kim (2010) used two different frameworks for interaction analysis in their study. They used social network analysis (SNA) to analyze the interaction patterns among group members and content analysis to analyze the messages shared within each group.

According to the results, the target group of examined studies consisted of undergraduate and graduate students, researchers, teaching staff, undergraduate graduate students and teachers, respectively. Given that the reviewed studies focused on higher education, it is reasonable to expect that the target group primarily comprises undergraduate students, followed by graduate students. In addition, the fact that researchers generally work in universities makes it easier to work with university students in terms of easy access to the sample. This may have led to the inclusion of undergraduate and graduate students in the target group. When the characteristics of the sample group in the target groups of the studies were examined, 4 themes were formed as students (undergraduate and graduate students), undergraduate graduate students, researchers, lecturers and teachers. The students (undergraduate and graduate students) are pre-service teachers, engineering, computer science, computer systems students, medical faculty, medical department students, social education and business students, physics department students, chemistry department students, social and educational policy students, learning sciences graduate students, economics department students, fine arts department students, biology department students, psychology department students, language department students, public administration students, management and politics, women's rights department students, psychology, adult graduate students participating in professional development courses/courses, industrial design engineers and business management students, and STEM program students. It was determined that pre-service teachers were predominant among the students. Considering that the research focuses on educational sciences studies at the higher education level, it is noteworthy that a significant number of researchers working in this domain are affiliated with Faculties of Education. This affiliation provides them with convenient access to pre-service teachers, which could have influenced the obtained results. This is followed by engineering students and then students studying in medical and medical departments. In some studies, the characteristics of the target group could not be determined because they were not disclosed.

The sample sizes in the studies were found to vary between 3 and 4337. It was determined that the highest number of samples in the studies was in the range of 31-60, followed by sample sizes of 1-31, 101-150, 201-300, respectively. There are 3 studies in which the number of target audience is larger than 1000. One of these three studies examines the effect of students' participation in discussion forums on their achievement in Massive Open Online Courses. With a substantial sample size of 4,337, it is believed that the accessibility and openness of MOOCs, being available to everyone free of charge and at a distance, played a crucial role in attracting such a high number of participants. Despite the structure of social network analysis that facilitates the analysis of large data, it is noteworthy that there are not many studies on large student groups. Furthermore, among the eight studies, it was noted that more than one study was conducted in some cases, resulting in varying sample sizes. Specifically, seven studies analyzed two different samples each, while one study delved into the analysis of seven distinct samples.

Upon examination of the sample selection methods employed in the articles included in the study, it becomes evident that convenience sampling is the predominant approach of choice. It is possible that this

sample selection method is preferred because it is easy to access and provides speed or practicality. In addition to this method, it was determined that a small number of purposive sampling methods were used, and systematic sampling method were used in only one study.

5. Recommendations

This research presents a comprehensive analysis of higher education studies that employ social network analysis, conducted via the method of content analysis.

Given the rising trend in social network analysis publications in higher education and the geographic distribution of authors in these publications, there is a clear need for increased knowledge, experience, and output in this field in several countries such as Turkey. As such, initiatives like courses, seminars, and workshops aimed at equipping individuals with conceptual understanding and practical application skills for social network analysis could be highly beneficial.

There's a notable scarcity of studies on peer assessment and collaborative assessment. Considering the importance of alternative assessment methods and the interpersonal interactions involved in these assessments, conducting Social Network Analysis (SNA) studies on these concepts would prove advantageous.

While social network analysis inherently supports big data analysis, only a few studies used large samples, with merely three involving over 1,000 participants. Education stakeholders can easily access interaction data from environments like massively open online courses and multimedia sharing platforms. Engaging larger samples in future studies could yield more comprehensive insights into user behavior, offering valuable information about learning processes, facilitating learning improvement, and informing educational policies at a national level.

This study involved a decade-long examination of SNA studies in higher education. Future research could utilize longitudinal network analyses, conducting content analysis over set intervals, and examining the changes and significance of the findings during these intervals. This would allow for the analysis of changes over 5 or 10 years and the identification of the reasons (methods, techniques, concepts, technologies, etc.) behind these changes.

Certain findings from the content analysis of this study could be further scrutinized through a secondary analysis using the social network analysis (SNA) method, providing more in-depth results. For instance, an investigation could be carried out to explore the relationships between the identified themes related to the foundational models, theories, and concepts and the themes tied to learning environments. This could lead to the development of a bimodal network structure study, illuminating the frequency and importance of certain concepts within specific learning environments and uncovering under-researched connections.

References

Alonso, F., Manrique, D., Martínez, L., & Viñes, J. M. (2015). Study of the influence of social relationships among students on knowledge building using a moderately constructivist learning model. *Journal of Educational Computing Research*, *51*(4), 417-439.

Baki, A., ve Gökçek, T. (2012). Karma Yöntem Araştırmalarına Genel Bir Bakış. *Electronic Journal of Social Sciences, 11*(42).

Biancani, S., & McFarland, D. A. (2013). *Social networks research in higher education.* In Higher education: Handbook of theory and research (pp. 151-215). Springer, Dordrecht.

Bruun, J., & Brewe, E. (2013). Talking and learning physics: Predicting future grades from network measures and Force Concept Inventory pretest scores. *Physical Review Special Topics-Physics Education Research*, *9*(2), 020109.

Büyüköztürk, Ş., Akgün, Ö. E., Demirel, F., Karadeniz, Ş., & Çakmak, E. K. (2015). *Bilimsel araştırma yöntemleri* (14.baskı)*. Ankara: Pegem Akademi.

Carolan, B. V. (2014). *Social network analysis and education: Theory, methods & applications*. Thousand Oaks, CA: SAGE.

Cela, K. L., Sicilia, M. Á., & Sánchez, S. (2015). Social network analysis in e-learning environments: A preliminary systematic review. *Educational Psychology Review, 27*(1), 219-246.

Chan, J. W., & Pow, J. W. (2020). The role of social annotation in facilitating collaborative inquiry-based learning. *Computers & Education*, *147*, 103787.

Chen, B., & Huang, T. (2019). It is about timing: Network prestige in asynchronous online discussions. *Journal of Computer Assisted Learning*, *35*(4), 503-515.

Cohen, L. M., Manion, L., & Morrison, K. (2007). *Research methods in education.* New York: Routledge.

Cross, R., Parker, A., & Borgatti, S. P. (2002). A bird's-eye view: Using social network analysis to improve knowledge creation and sharing. In *IBM Institute for Business Value* (Vol. 2). Somers, NY: IBM Corporation.

Çalık, M., & Sözbilir, M. (2014). İçerik analizinin parametreleri. *Eğitim ve Bilim, 39*(174), 33-38.

Dawson, S. (2010). 'Seeing'the learning community: An exploration of the development of a resource for monitoring online student networking. *British journal of educational technology*, *41*(5), 736-752.

Dinçer, S. (2018). Eğitim bilimleri araştırmalarında içerik analizi: Meta-analiz, meta sentez, betimsel içerik analizi. *Bartın Üniversitesi Eğitim Fakültesi Dergisi, 7*(1), 176-190.

Ellis, R. A., Han, F., & Pardo, A. (2019). When does collaboration lead to deeper learning? Renewed definitions of collaboration for engineering students. *IEEE Transactions on Learning Technologies*, *12*(1), 123-132.

Freeman, L.C. (2006). *The development of social network analysis: A study in the socıology of scıence.* Vancouver: ΣP Empirical Press.

Froehlich, D. E., Van Waes, S., & Schäfer, H. (2020). Linking quantitative and qualitative network approaches: A review of mixed methods social network analysis in education research. *Review of Research in Education*, *44*(1), 244-268.

Gillani, N., & Eynon, R. (2014). Communication patterns in massively open online courses. *The Internet and Higher Education*, *23*, 18-26.

Grunspan, D. Z., Wiggins, B. L., & Goodreau, S. M. (2014). Understanding classrooms through social network analysis: A primer for social network analysis in education research. *CBE—Life Sciences Education*, *13*(2), 167-178.

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of educational computing research*, *17*(4), 397-431.

Heo, H., Lim, K. Y., & Kim, Y. (2010). Exploratory study on the patterns of online interaction and knowledge co-construction in project-based learning. *Computers & Education*, *55*(3), 1383-1392.

Jan, S. K., Vlachopoulos, P., & Parsell, M. (2019). Social Network Analysis and Learning Communities in Higher Education Online Learning: A Systematic Literature Review. *Online Learning*, *23*(1).

Jo, I., Park, Y., & Lee, H. (2017). Three interaction patterns on asynchronous online discussion behaviours: A methodological comparison. *Journal of Computer Assisted Learning*, *33*(2), 106-122.

Gerlach, J. M. (1994). Is this collaboration? In Bosworth, K. & Hamilton, S. J. (Eds.), *Collaborative Learning: Underlying Processes and Effective Techniques, New Directions for Teaching and Learning, No. 59*. (pp.5-14). San Francisco: USA, Jossey-Bass.

Gewerc, A., Montero, L., & Lama, M. (2014). Collaboration and social networking in higher Education. *Comunicar*, 42, 55-62.

Hew, K. F., Cheung, W. S., & Ng, C. S. L. (2010). Student contribution in asynchronous online discussion: A review of the research and empirical exploration. *Instructional science*, *38*, 571-606.

Kim, D., Park, Y., Yoon, M., & Jo, I. H. (2016). Toward evidence-based learning analytics: Using proxy variables to improve asynchronous online discussion environments. *The Internet and Higher Education*, *30*, 30-43.

Liu, X., Magjuka, R. J., Bonk, C. J., & Lee, S. (2007). Does sense of community matter? *The Quarterly Review of Distance Education, 8*(1), 9–24.

McLaughlin, M. W. & Talbert, J. E. (2006). *Building school-based teacher learning communities: Professional strategies to improve student achievement* (Vol. 45). Teachers College Press.

McGloin, J. M., & Kirk, D. S. (2014). An overview of social network analysis. *Advancing Quantitative Methods in Criminology and Criminal Justice*, 67-79.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

Moolenaar, N.M. (2012). A social network perspective on teacher collaboration in schools: Theory, methodology and applications. *American Journal of Education, 119*, 7-39.

Morgan, D. L. (1998). Practical strategies for combining qualitative and quantitative methods: Applications to health research. *Qualitative health research, 8*(3), 362-376.

Moskal, B. M., & Leydens, J. A. (2000). Scoring rubric development: Validity and reliability. *Practical assessment, research, and evaluation*, *7*(1), 10.

Scott, J. (2000). *Social network analysis: A handbook*. London: Sage.

Senemoğlu, N. (2007). *Gelişim öğrenme ve öğretim kuramdan uygulamaya.* Ankara: Pegem.

Somyürek, S. ve Güyer, T. (2020). Social Network Analysis. Educational Data Mining and Learning Analytics, Güyer, T., Yurdugül, H., & Yıldırım, S. (Editor), Anı Publications ISBN: 978-605-170-379-4.

Sun, Z., Liu, R., Luo, L., Wu, M., & Shi, C. (2017). Exploring collaborative learning effect in blended learning environments. *Journal of computer assisted learning*, *33*(6), 575-587.

Tabassum, S., Pereira, F. S., Fernandes, S., & Gama, J. (2018). Social network analysis: An overview. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *8*(5), e1256.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications.* Cambridge: Cambridge University.

We are Social (2020). Digital in 2020. Retrieved from https://wearesocial.com/blog/2020/01/digital-2020-3-8-billion-people-use-social-media

Wu, D., & Hiltz, S. R. (2004). Predicting learning from asynchronous online discussions. *Journal of asynchronous learning networks*, *8*(2), 139-152.