AWARI
Vol. 4, 2023. 1-10, DOI: 10.47909/awari.56

Pro-Metrics

REVIEW ARTICLE

Relationship between density and recoverability in social networks

Tulio Andrés Clavijo Gallego[I], **Verenice Sánchez Castillo**[II]

[I] Universidad del Cauca, Colombia.
Email: t.clavijo@unicauca.edu.co
ORCID: 0000-0003-3737-0542

[II] Universidad de la Amazonia, Colombia.
Email: ve.sanchez@udla.edu.co
ORCID: 0000-0002-3669-3123

ABSTRACT

The paper explores elements of the existing literature to investigate the complex relationship between the density of social networks and their resilience to shocks. Density and recoverability are key concepts in understanding the strength of social networks. It discusses how a dense social network can facilitate communication recovery by providing multiple pathways for reorganization and mutual support among users. However, it can also lead to rigidity and vulnerability to targeted attacks or systematic failures. The importance of an optimal balance between the density of a network and the diversity of its connections to maximize its recoverability is explored, along with the role of digital technology and social networking platforms in changing these dynamics. The article concludes with recommendations for future research and other considerations for designing and managing resilient social networks, focusing on the need for a better understanding of the interplay between network structures, social dynamics, and the external factors that influence them.

Keywords: social network density; network recoverability; social network resilience; network structure.

INTRODUCTION

In the contemporary digital era, social networks have established themselves as crucial platforms for human interaction, information exchange, and community formation. Such are the cases of the student research hotbeds in Colombia, a leading country in this organizational line of training in high study centers (Gómez Cano, 2022). However, in university training, the development of digital skills is essential, which can ensure the comprehensive development of future professionals as long as they receive continuous training in the field of these technologies in the formation of a solid base for working on networks that are supported by an adequate information culture (López, 2023).

In this latter environment, Juárez-Escribano (2020) states that the internet constitutes a platform that contains several cultures grouped in social networks, always derived from the latter's designs, decisions, and products. One of them is university, where it is possible to find interactive systems such as Moodle, a useful platform for developing teaching-learning processes. Currently, general references are made to the Internet of Things or objects based on

How to cite: Gallego, T. A. C., & Castillo, V. S. (2023). Relationship between density and recoverability in social networks. *AWARI; 4*, 1-10. DOI: 10.47909/awari.56.

Received: 21-03-2023 / **Accepted:** 09-06-2023 / **Published:** 15-06-2023
Editor: Adilson Luiz-Pinto

AWARI
Vol. 4, 2023. 1-10, DOI: 10.47909/awari.56

existing interactions with people, groups, and devices in the virtual world. The above elements lead, among other tasks, to the consistent preparation of professionals in acquiring digital skills (Díaz, 2018) (Kumar, 2019). The importance of this issue is also found in centralized networks (Mosleh *et al.,* 2024) and their influence on women and underrepresented minorities (Wao *et al.,* 2023). These networks not only facilitate connections between geographically dispersed individuals, but they also act as catalysts for the exchange of ideas, social mobilization, and the creation of social capital in the training of professionals by incorporating them into university teaching processes (Gómez Cano *et al.,* 2017). However, to achieve entrepreneurship skills in students as replacements for current professionals, the use of tools and proposals for innovative solutions is required (Ripoll, 2023). The study and management of digital technologies constitute a substantial element of a continuous learning process (Ruiz, 2023) with didactic strategies that encouraged the virtual teaching-learning modality during the COVID-19 pandemic (Miranda & Sanabria, 2023).

The incidence of the SARS-CoV-2 virus was also shown in the survival of small and medium-sized public companies, as pointed out by Trawnih *et al.,* (2021) when discussing the issue in the area of the countries of the Balkan Peninsula, but with universal impact. In this pandemic context, complex networks have been a great candidate for the analysis of these systems due to their ability to address structural and dynamic properties (Scabini *et al.,* 2021).

However, the robustness of these networks in the face of disruptions, whether cyber attacks, disinformation campaigns, or abrupt changes in social dynamics (Michail *et al.,* 2022), raises significant questions about their resilience in resisting changes (Qi & Mei, 2024; Ward *et al.,* 2020). This last category, as a concept, has complex characteristics and presents numerous approaches in different fields of research. This problem has been addressed by Liu *et al.,* (2022) and by authors from King Saud University, who propose a methodological framework for measuring and evaluating network resilience.

Exploring the complex relationship between the density of social networks – the number of connections between members within a network concerning the total number of possible connections – and their recoverability becomes crucial. Some authors emphasize the threats that networks frequently receive, as well as phishing, malware, cyberbullying, and trolling attacks with disinformation and the creation of network vulnerability (Martínez *et al.,* 2021).

Recoverability, defined as the ability of a network to maintain or quickly recover its structure and function after a disruption, emerges as a key concept for understanding the resilience and sustainability of social media platforms.

IMPORTANCE OF NETWORK DENSITY

The term density is recognized as the number of connections between subjects within a network and their relationship with the possible connections. This category is presented as an indicator of internal cohesion and the intensity of interactions between users. Networks with high density tend to exhibit a greater propensity for information sharing and, potentially, greater uniformity in shared norms and values.

However, this density level can give rise to technological insufficiencies since while the dissemination of information is facilitated, it can also lead to the homogenization of opinions and, in extreme cases, to polarization. In the context of disruptions, a dense network could be more susceptible to the spread of disinformation or the impact of coordinated attacks, raising questions about how the structure of these networks influences their ability to withstand and recover from such events. In these issues, it is necessary to recognize the importance of social networks, both in the dissemination and dissemination processes of science and their effects on the development and competitiveness of productive and service organizations (Sánchez *et al.,* 2017).

RECOVERABILITY AS A MEASURE OF NETWORK RESILIENCE

According to Dong & Chia (2022) and Rochman *et al.,* (2023)), referring to the dynamic resistance of network systems requires defining their recovery capacity, which leads to the adjustment of their tasks and functions against external disturbances. In other words, the recovery capacity of social networks is synonymous

with the speed and effectiveness with which they can restore their basic functionality and the integrity of their social structure after suffering disturbances. Such is the case of optical networks that show vulnerability to topological disturbances with changes in the connection forms of their links (Peng *et al.,* 2021).

This concept encompasses both the restoration of connections between users and the preservation of the quality and accessibility of the information shared within the network. Recoverability indicates the network's resilience and ability to adapt and maintain its operability in the face of unforeseen changes and challenges. Documented studies on networks such as Twitter show that existing tools amplify misinformation, making it difficult to control (Muñoz & Bellogín, 2024). However, the journalistic dynamics in networks studied by South *et al.,* (2022) on the development of information flows and the evaluation of content has allowed the production of new tools for this purpose, opening new fields of knowledge.

In a world where cyber threats and disinformation campaigns are increasingly effective, understanding the factors that contribute to the recoverability of social networks is essential to designing more robust and resilient platforms.

THE INTERCONNECTION BETWEEN DENSITY AND RECOVERABILITY OF NETWORKS

Network density is the relationship between the number of actual links and the possible or potential links in a network. A potential or possible link is a connection that potentially exists between two nodes (Bhattacharya *et al.,* 2023). The interaction between the density of a network and its recoverability after disturbances constitutes a relationship that depends mainly on variables such as the nature of the disturbance, the specific characteristics of the network (for example, the distribution of centrality among users), as well as the platform's governance policies and content moderation.

A limitation of the most widely used network scales is their lack of ability to measure density or connections between network members, and to date few works can be found focused on network density and its association with health outcomes and the final points. By assuming the level of importance of the density of a network, Brughmans & Peeples (2023) insist on the need to apply network exploration methods based on obtaining responses linked to that and other indicators, such as the most central nodes and the average length. of a path through the network.

METHODOLOGY

To investigate the relationship between density and recoverability in social networks, a methodological approach was adopted focused on reviewing the literature and analyzing guidelines related to the dynamics of social networks. This analysis included an examination of the origins, evolution, and implementation of key concepts within the realm of social media, focusing on how these aspects contribute to the resilience and recovery capacity of said platforms.

The methodology was based on the principles of grounded theory, a qualitative approach that allows the generation of theories through the systematic collection, review, and comparison of data (Pérez *et al.,* 2021). This approach is particularly suitable for exploring complex and multifaceted areas such as social networks, where the density of connections and their impact on recoverability after disturbances constitute an emerging field of study.

A search of documentary sources was carried out that essentially included the SCOPUS and SPRINGER NATURE databases, to obtain the necessary information to support the construction of new knowledge on the topic under study. For this purpose, the keywords "density of social networks", "recoverability of networks" and "resilience of platforms" were mainly used. The literature review was designed to identify current trends, relevant issues, and future research opportunities that can facilitate the formulation of innovative theoretical models and hypotheses that reflect the current dynamics of social networks in terms of density and their ability to recover from disruptions or significant changes.

This methodological approach provides a platform for understanding the interaction between the structure of social networks and their post-disruption functionality. It underlines the importance of network density as a critical factor in its ability to maintain or quickly recover its normal structure and operations.

AWARI
Vol. 4, 2023. 1-10, DOI: 10.47909/awari.56

RESULTS

The great changes that have occurred in recent years on our planet have generated the insertion of social networks in the economy around the flow of data, information, and knowledge as another form of organization of human activity. These are nodes of subjects, groups, organizations, and systems that, although they exhibit differences, are related to each other and can share conflicts, ideas, and other processes of human activity. The defining characteristic of social network analysis is that it focuses on the structure of relationships, which contrasts with different spheres of social sciences by focusing attention on the relationships between the so-called agents of the processes (Serrat, 2017).

FACILITATION OF RECOVERY DUE TO GREATER DENSITY

Network density is a property that affects its efficiency, especially those linked to innovative processes. However, as stated by Hua & Shao (2022), there is still no adequate and adjusted understanding of this characteristic. In this sense, Moser & Smaldino (2023) highlight the positive influence on the innovation of the size and rates of information exchange in networks, which suggests the study of the incidence of the behavior of individuals and the role they play in groups to whom they belong. It is necessary to note that neither rigid nor volatile networks promote innovation and that its place (locus) is found in inter-organizational networks. Mannak *et al.,* (2023) state that high density is characterized by a significant number of connections between network members, fostering an environment where mutual support and reorganization can occur more efficiently and effectively. In networks, properly managing the availability of "packets" of flows in large data centers and their servers is vital since their performance is related to information processing speed (Liu & Lui, 2020).

A network of dense connections creates multiple channels through which information and support can flow quickly, which is essential in the immediate aftermath of a disruption. The presence of multiple paths for communication and resource exchange increases the network's ability to self-organize and adapt to new conditions, promoting a more agile and robust recovery.

STIFFNESS AND VULNERABILITY DUE TO HIGH-DENSITY

The density that facilitates network recovery can introduce rigidity and increase its vulnerability to targeted attacks or systematic failures. Vulnerability in networks is currently a problem that requires great attention in institutions, given the influences they can exert on the opinions and behavior of those with access to information. For this reason, some authors, such as Bruning *et al.,* (2020), propose concepts for its proper management, such as commitment, self-management, and reliability.

Networks with high density can develop highly predictable and centralized interaction patterns, making them susceptible to attacks that target critical nodes or connections. This centralization can lead to over-reliance on certain nodes or groups within the network, where their compromise or failure could have disproportionately disruptive effects. Furthermore, density can contribute to forming an "echo chamber", where information redundancy and opinion homogenization compromise the network's ability to incorporate new information and adapt to changes, increasing its rigidity and reducing its overall resilience.

BALANCING BENEFITS AND CHALLENGES OF DENSITY

According to this analysis, the key to maximizing recoverability and minimizing vulnerability lies in finding an optimal balance in network density. This balance allows you to leverage the benefits of a densely connected network for rapid recovery while mitigating the risks associated with rigidity and vulnerability to attacks. Network governance mechanisms, such as content moderation policies, diversifying connections, and implementing strategies to increase the resilience of critical nodes, can play significant roles in this balance.

IMPLICATIONS FOR SOCIAL MEDIA DESIGN

The above elements underscore the importance of carefully considering network structure when designing and implementing social media platforms. Cantor *et al.,* (2021) point out that the complex interaction between

population size, structure, and transmission mechanisms has important implications for future research. However, they affirm that there is still not enough clarity about the relative importance of the structure of networks, the reasons why it is necessary to investigate the architecture of social networks, and the pace of cultural evolution.

To foster resilient communities, system designers should strive to create network architectures that promote the density of connections to facilitate recovery and mutual support and incorporate mechanisms to avoid excessive centralization and encourage diversity and flexibility. Deploying advanced analytical tools to monitor network health and detect early signs of tightness or vulnerability can be essential to maintaining network dynamics in an optimal state of resilience.

BALANCE BETWEEN DENSITY AND DIVERSITY

The above analysis shows that social networks with an optimal balance between the density of connections and their diversity exhibit remarkable resilience against external and internal perturbations. This balance allows networks to benefit from the rapid dissemination of information characteristic of dense networks while protecting themselves against the risks associated with homogenization and vulnerability to attacks, thanks to the robustness provided by diversity. This characteristic in the connections introduces a variety of perspectives and information essential for the innovation and adaptability of the network.

DEEPENING THE ROLE OF DIGITAL TECHNOLOGY

Digital technology floods the social universe. Scientific training is shown on academic platforms (Cardeño & Bonilla, 2023); among the most used are messaging and social networks (Gómez *et al.,* 2017). However, technological development opens new doors to virtual environments such as the metaverse, which, although it still has its limitations, must provide unsuspected advances in vocational training processes (González *et al.,* 2023; Anacona *et al.,* 2019).

The influence of digital technology on shaping the density and diversity of social networks is multifaceted. Recommendation algorithms, for example, have the power to reinforce existing connection patterns and introduce users to new networks and content. However, there is a worrying trend towards the reinforcement of filter bubbles. These algorithms generate obstacles to communication between users of a network and the segregation of the community on many recognized platforms for social communication. This phenomenon reduces the network's overall ability to adapt and recover from disruptions.

In this context, Sanz-Cruzado & Castells (2018) state that the diversity of link recommendations in the flow of information through the network may have potential implications for mitigating filter bubbles. Designers of social media platforms must reconsider how technologies on social media platforms affect dynamics and explore new ways to promote a greater diversity of connections.

DETERMINING THE INFLUENCE OF SOCIAL MEDIA PLATFORMS

Social media platforms are facilitators of social interaction and active configurators of the social structure in the digital space. They determine spaces in knowledge management and university development, essentially in decision-making (Pérez *et al.,* 2022). In the latter case, the use of Moodle and its link with WhatsApp as effective teaching platforms is known (Pérez, 2022) both in educational guidance and in the training process itself. Elements that corroborate Peña *et al.,* (2022) on the use of virtual technologies in the context above. To this end, the importance of the design and policy decisions of these platforms in promoting resilient network structures must be highlighted. Those platforms that actively promote interaction between diverse groups and facilitate meaningful connections beyond immediate social circles tend to be better able to withstand and recover from disruptions. This places considerable responsibility on platform designers to create socially enriching and resilient environments by designing their structures.

AWARI
Vol. 4, 2023. 1-10, DOI: 10.47909/awari.56

DYNAMICS ALTERED BY DIGITAL TECHNOLOGY

The interaction between users on social networks and how it is influenced by digital technology reveals a complex network of factors that affect density and diversity. Features such as instant messaging systems and discussion forums can increase the density of interactions, while personalized recommendations and interest groups can expand the diversity of connections. Han (2023) emphasizes the importance of interpersonal relationships with social support in communication through social networks. Others, such as Pérez *et al.,* (2023), refer to the latter's benefits regarding creating capabilities in digital technologies. However, Miranda *et al.,* (2023) evaluate the global effect of addicted media on the public. Valladolid *et al.,* (2023) affirm that in Peru, the development of addiction (and obsession) to these networks by university students is notable and suggest the study of the issue and the search for solutions that mitigate the negative effects of the inappropriate use of virtual platforms.

It should be highlighted how these tools can be adjusted to improve the network's resilience, suggesting a more dynamic and adaptive approach in designing platform functionalities that considers the balance between maintaining cohesive communities and encouraging the exploration of new connections. The role and importance of networks have been evaluated by Mercadé-Melé *et al.,* (2017) when comparing them with information management and the effectiveness of the press in disseminating socially responsible activities. These authors have found differences between the media above and their effects on the public and highlight the importance of networks. In the same sense, O¨zkent (2022) reports that scientific articles displayed on social media have higher citation rates than those that are not linked to networks, reasons why they suggest researchers carry out targeted projects to increase the employment of the latter, an element corroborated by Zhang *et al.,* (2020) and Smith *et al.,* (2019).

FINAL CONSIDERATIONS

Social networks constitute a powerful management tool in the search for successful performances by generating advantages in the competitive order and the sustainability of the processes (Limas & Sierra. 2023). Up to this point, a crucial aspect in the field of social networks is addressed: the interaction between the network structure, internal social dynamics, and external factors, and how these joint elements influence the resilience and recovery capacity of networks against disturbances. From the previous elements, the prevailing need to deepen the understanding of these complex interactions is evident to improve both the design and management of resilient social media platforms.

The above analysis reveals that a detailed understanding of the network structure is essential to predict and improve its resilience. The density of the network, the centrality of the nodes, and the diversity of connections are determining factors that can significantly influence the resilience of a network.

It has been observed that networks with an optimal balance between density and diversity are better able to adapt and recover from external shocks, thanks to their ability to facilitate efficient information flow and sustain robust mutual support among their members. However, it is also noted that excessive density can generate rigidity and vulnerability to targeted attacks, highlighting the complexity of finding the ideal structure that promotes maximum resilience.

In parallel, social dynamics within social networks, including group formation, shared norms, and communication practices, play a crucial role in determining a network's response to disturbances. Networks that cultivate a culture of mutual support and collaboration tend to show a greater ability to organize and recover from disruptive events. These elements underscore the importance of governance policies and moderation tools that foster healthy and constructive interactions, balancing freedom of expression with the need to maintain the integrity and cohesion of communities.

It has been identified that external factors, such as technological advances, changes in legislation, and socio-political movements, can have profound effects on the structures and dynamics of social networks, altering their capacity for recovery. The adaptability of social networks to these external factors emerges as a critical area of study, suggesting the need

for strategies to anticipate and mitigate such changes' negative impacts.

For this reason, the importance of designing and managing social media platforms with a comprehensive perspective that considers the structure of the network, social dynamics, and external factors is emphasized. This includes the development of interfaces and algorithms that promote diversity and resilience, as well as implementing policies that promote community cohesion and the capacity to adapt. Creating early warning systems and rapid response mechanisms can be vital to maintaining the stability and health of social networks in the face of unforeseen challenges.

The inherent complexity of social networks and the need for a collaborative approach between researchers, platform designers, and community managers to develop more resilient and adaptive networks is evident. By advancing the understanding of how network structure, social dynamics, and external factors influence resilience, we can aim to create digital environments that better resist disruptions and promote a healthier space and sustainable social interaction.

This research highlights the complexity inherent in the relationship between the density of social networks and their recovery capacity. While greater density can provide a solid foundation for mutual support and rapid recovery, it also carries the risk of increasing rigidity in those processes with networks vulnerable to targeted attacks or systematic failures. The results of this study accentuate the complexity inherent in social network management and the need for a balanced approach that considers both the density and diversity of connections to maximize resilience. Digital technology and platform policies are crucial in this balance, offering opportunities and challenges for shaping resilient social networks.

Conflict of interest

The authors declare no conflict of interest related to this work. ●

REFERENCES

Anacona Ortiz, J. D., Millán Rojas, E. E., & Gómez Cano, C. A. (2019). Aplicación de los metaversos y la realidad virtual en la enseñanza. *Entre ciencia e ingeniería, 13*(25), 59-67. https://doi.org/10.31908/19098367.4015

Bhattacharya S, Sinha S, Dey P., Saha A., Chowdhury Ch, Roy S. (2023). Chapter 5 - Online social-network sensing models. In Hybrid Computational Intelligence for Pattern Analysis and Understanding. Computational Intelligence Applications for Text and Sentiment Data Analysis. Editor(s): Dipankar Das, Anup Kumar Kolya, Abhishek Basu, Soham Sarkar, *Academic Press*. 113-140

Brughmans, T., & Peeples, M. A. (2023). Exploratory Network Analysis. In *Network Science in Archaeology* (pp. 103-148). Chapter, Cambridge: Cambridge University Press.

Cantor, M., Chimento, M., Smeele, S. Q., He, P., Papageorgiou, D., Aplin, L. M., & Farine, D. R. (2021). Social network architecture and the tempo of cumulative cultural evolution. *Proceedings. Biological sciences, 288*(1946), 20203107. https://doi.org/10.1098/rspb.2020.3107

Cardeño, N., Cardeño, E. y Bonilla, E. (2023). TIC y transformación académica en las universidades. *Región Científica, 2*(2), 202370. https://doi. org/10.58763/rc202370

Díaz, N. M. 2018. Redes sociales, Internet de las cosas y competencias digitales de profesores e investigadores en Medicina. *Revista Cubana de Educación Médica Superior. 32*(2):1-16. http://scielo.sld.cu/pdf/ems/v32n2/a22_1363.pdf

Dong G, Duan D and Xia Y. (2022). Editorial: Network resilience and robustness: Theory and applications. *Front. Phys*. 10:972037. doi: 10.3389/fphy.2022.972037

Gómez Cano, C. A., Sánchez Castillo, V., & Ramón Polanía, L. (2017). Incorporar las TIC a los procesos de enseñanza-aprendizajez: Una lectura desde el actuar docente en educación superior. *Horizontes Pedagógicos. 19*(1). https://revistas.iberoamericana.edu.co/index.php/rhpedagogicos

Gonzales Tito YM, Quintanilla López LN, Pérez Gamboa AJ. (2023). Metaverse and education: a complex space for the next educational revolution. *Metaverse Basic and Applied Research*. 2:56. https://doi.org/10.56294/mr202356

Gómez Cano, C. A. (2022). Ingreso, permanencia y estrategias para el fomento de los Semilleros de Investigación en una IES de

AWARI
Vol. 4, 2023. 1-10, DOI: 10.47909/awari.56

Colombia. *Región Científica, 1*(1), 46-56. https://doi.org/10.55204/rc.v1i1.28

Han R. More. (2023). Talk, More Support? The Effects of Social Network Interaction and Social Network Evaluation on Social Support via Social Media. *Psychol Res Behav Manag.* 16:3857-3866. https://doi.org/10.2147/PRBM.S424443

Hua, L., Yang, Z., & Shao, J. (2022). Impact of network density on the efficiency of innovation networks: An agent-based simulation study. *PloS one, 17*(6), e0270087. https://doi.org/10.1371/journal.pone.0270087

Juárez - Escribano MB. (2020). Análisis de la cultura virtual en las redes sociales como organización digital. *Revista Prisma Social*. (30):295-321. https://revistaprismasocial.es/article/view/3550

Kumar S., Tiwari P., & Zymbler M. (2019). Internet of Things is a revolutionary approach for future technology enhancement: a review. *J Big Data* 6:111 https://doi.org/10.1186/s40537-019-0268-2

Liu, X., Li, D., Ma, M., Szymanski, B. K., Stanley, H. E., & Gao, J. (2022). Network resilience. *Physics Reports,* 971, 1-108. https://doi.org/10.1016/j.physrep.2022.04.002

López, Y. (2023). Aptitud digital del profesorado frente a las competencias TIC en el siglo xxi: una evaluación de su desarrollo. *Región Científica, 2*(2), 2023119. https://doi.org/10.58763/ rc2023119

Liu T. & Lui JSC. (2020). FAVE: A Fast and Efficient Network Flow Availability Estimation Method With Bounded Relative Error. *IEEE/ACM transactions on networking.* https://www.researchgate.net/publication/331769197_FAVE_A_fast_and_efficient_network_Flow_AVailability_Estimation_method_with_bounded_relative_error

Limas Suárez, S. J., y Sierra Forero, L. E. (2023). Uso de las redes sociales como herramienta de gestión administrativa en el sector empresarial. *Revista CEA, 9*(19), e2307. https://doi.org/10.22430/24223182.2307

Miranda, S., Trigo, I., Rodrigues, R., & Duarte, M. (2023). Addiction to social networking sites: Motivations, flow, and sense of belonging at the root of addiction. Technological *Forecasting and Social Change, 188,* 122280. https://doi.org/10.1016/j.techfore.2022.122280

Mercadé-Melé P., & Molinillo S., Fernández-Morales. A. (2017). Marketing and Corporate Social Responsibility. *21*(S1): 54-64. DOI: 10.1016/j.sjme.2017.04.003

Moser, C., & Smaldino, P. E. (2023). Innovation-facilitating networks create inequality. Proceedings. *Biological Sciences, 290*(2011), 20232281. https://doi.org/10.1098/rspb.2023.2281

Mannak, R., Markus, A., Meeus, M., Raab, J., & Smit, A. C. (2023). Network dynamics and its impact on innovation outcomes: R&D consortia in the Dutch water sector. *Social Networks, 74,* 62-70. https://doi.org/10.1016/j.socnet.2023.02.004

Martínez Chérrez, W. E., Ávila Pesantez, D. F. (2021). Ciberseguridad en las redes sociales: una revisión teórica. *Uniandes Episteme, 8*(2), 211-234.

Michail, D., Kanakaris, N., & Varlamis, I. (2022). Detection of fake news campaigns using graph convolutional networks. *International Journal of Information Management Data Insights, 2*(2), 100104. https://doi.org/10.1016/j.jjimei.2022.100104

Miranda, M. y Sanabria, M. (2023). Estrategias didácticas en plataformas educativas: experiencia de docentes de Licenciatura en Administración en universidad pública de Paraguay. *Región Científica, 2*(1), 202330. https://doi.org/10.58763/rc202330

Mosleh, L., Yore, M., Wells, W., Eisenman, D. P., & Schwarz, K. (2024). A social network analysis of cross-organizational engagement for urban heat resilience in Los Angeles County, California. *Urban Climate, 53,* 101797. https://doi.org/10.1016/j.uclim.2023.101797

Muñoz, P., Díez, F. & Bellogín. (2024). A. Modeling disinformation networks on Twitter: structure, behavior, and impact. *Appl Netw Sci. 9*(4): 1-35. https://doi.org/10.1007/s41109-024-00610-w

O¨zkent Y. (2022) Social media usage to share information in communication journals: An analysis of social media activity and article citations. *PLoS ONE 17*(2): e0263725. https://doi. org/10.1371/journal.pone.0263725

Patrick F. Bruning, Bradley J. Alge, Hsin-Chen Lin. (2020). Social networks and social media: Understanding and managing influence vulnerability in a connected society. *Business Horizons 63* (6): 749-761. https://doi.org/10.1016/j.bushor.2020.07.007

Pérez Gamboa AJ, Echerri Garcés D, Garcia-Acevedo Y. (2021). Proyecto de vida como categoría de la pedagogía de la Educación Superior: aproximaciones a una teoría fundamentada. *Transformacion. 17* (3), 542-563. http://orcid.org/0000-0002-4138-2880 Yanetsy García Acevedo1,

Pérez Gamboa AJ., Gómez Cano CA., Sánchez Castillo V. (2022). Decision making in university contexts based on knowledge management systems. *Data and Metadata*. 1:92. https://doi.org/10.56294/dm202292

Pérez, A. (2022). La plataforma MOODLE como espacio para la acción orientadora. *Revista Varela, 22*(63), 181-190. https://revistavarela.uclv.edu.cu/index.php/rv/article/view/1428

Pérez, M., Torres L. & Hernández, M. (2023). Evaluación de las condiciones del Gabinete Psicopedagógico de la Universidad de Cienfuegos en la gestión de servicios de orientación virtual. *Región Científica, 2*(2), 202384. https://doi.org/10.58763/rc202384

Peña, Y., Díaz, K. y Contreras, Y. (2022). La virtualidad de la enseñanza para facilitar el autoaprendizaje en los estudiantes. *Revista Varela, 22*(63), 208-216

Qi, X., & Mei, G. (2024). Network Resilience: Definitions, approaches, and applications. *Journal of King Saud University - Computer and Information Sciences, 36*(1), 101882. https://doi.org/10.1016/j.jksuci.2023.101882

Ripoll, M. (2023). El emprendimiento social universitario como estrategia de desarrollo en personas, comunidades y territorios. *Región Científica, 2*(2), 202379. https://doi.org/10.58763/ rc202379

Rochman, G. P., Agustina, I. H., Fardani, I., & Astari, W. Y. (2023). *The Role of Social Networks in Strengthening Cirebon's. 39*(1).

Ruiz, V. (2023). Estrategias innovadoras para un aprendizaje continuo y efectivo durante emergencias sanitarias en Ciudad del Este. *Región Científica, 2*(1), 202338. https://doi.org/10.58763/rc202338

Sánchez, M. A., Schmidt, M. A., Zuntini, J. I., & Obiol, L. (2017). La influencia de las redes sociales virtuales en la difus ión de informac ión y conocimiento: estudio de PYMES. *Revista Ibero Americana de Estratégia. 16*(4): 69-90. https://www.redalyc.org/pdf/3312/331253804006.pdf

Serrat, O. (2017). Social Network Analysis. In: *Knowledge Solutions*. Springer, Singapore. https://doi.org/10.1007/978-981-10-0983-9_9

South, T., Smart, B., Roughan, M., & Mitchell, L. (2022). Information flow estimation: A study of news on Twitter. *Online Social Networks and Media, 31,* 100231. https://doi.org/10.1016/j.osnem.2022.100231

Sanz-Cruzado J & Castells P. (2018). Enhancing Structural Diversity in Social Networks by Recommending Weak Ties. In *Proceedings of the 12th ACM Conference on Recommender Systems (RecSys 2018),* Vancouver, BC, Canada, October 2018, 9 pages. DOI: 10.1145/3240323.3240371.

Scabini L. F. S., Ribas LC., Neiva MB., Junior AG.B., Farfán A J. F., Bruno OM. (2021). Social interaction layers in complex networks for the dynamical epidemic modeling of COVID-19 in Brazil. Physica A: Statistical Mechanics and its Applications. 564 ( ): https://doi.org/10.1016/j.physa.2020.125498

Smith ZL, Chiang AL, Bowman D, Wallace MB. (2019). Longitudinal relationship between social media activity and article citations in the journal Gastrointestinal Endoscopy. *Gastrointestinal Endoscopy. 90* (1):77-83. https://doi.org/10.1016/j.gie.2019.03.028 PMID: 30935934

Sun P., Zhidong H., Kooij RE., Van Mieghem P. (2021). Topological approach to measure the recoverability of optical networks. *Optical Switching and Networking 41*. https://doi.org/10.1016/j.osn.2021.100617

Trawnih, A., Yaseen, H., Al-Adwan, A. S., Alsoud, A. R., & Jaber, O. A. (2021). Factors influencing social media adoption among smes during COVID-19 crisis. *Journal of Management Information and Decision Sciences, 24*(6), 1-18

Valladolid Benavides, A. M., Neyra Cornejo, F. I., Hernández Hernández, O., Callupe Cueva, P. C., & Akintui Antich, J. P. (2023). Adicción a redes sociales en estudiantes de una universidad nacional de Junín (Perú). *Región Científica, 2*(1), 202353. https://doi.org/10.58763/rc202353

Wao, H., Kersaint, G., Smith, C. A. S., Campbell-Montalvo, R., Puccia, E., Skvoretz, J., Martin, J. P., Lee, R., & MacDonald, G. (2023). Examining how social networks

AWARI
Vol. 4, 2023. 1-10, DOI: 10.47909/awari.56

influence women and under-represented minority students' pursuit of engineering in university: When, who, and how? *International Journal of STEM Education, 10*(1), 25. https://doi.org/10.1186/s40594-023-00415-w

Ward, S., Meng, F., Bunney, S., Diao, K., & Butler, D. (2020). Animating inter-organisational resilience communication: A participatory social network analysis of water governance in the UK. *Heliyon, 6*(10), e05069. https://doi.org/10.1016/j.heliyon.2020.e05069

Zhang, Dafang MD., Earp Brandon E. MD. (2020). Correlation between social media posts and academic citations of Orthopaedic Research. *JAAOS: Global Research and Reviews*. *4*(9): e20.00151. DOI:10.5435/JAAOSGlobal-D-20-00151.