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Integration Between PMBOK 7th Concepts: A Network Analysis

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Abstract

PMBOK is a globally widely used guideline for project management. The release of the last version of this framework (the seventh edition) has been motivated by the rapid evolution of technology, new methodologies, swift market transitions, and significant transformations in the professional realm. The 7th edition has been revamped to accommodate these dynamic shifts, aiming to foster proactivity, innovation, and agility. It encompasses various development methodologies, from predictive to hybrid, and offers a dedicated section on customizing approaches and processes. The 7th edition further expands its toolkit by including the "Models, Methods, and Artifacts" segment, emphasizing project outcomes and deliverables. Another relevant change in this version is the transition from a hierarchical decomposition of PM knowledge to a comprehensive principles-based approach comprising eight performance domains: stakeholders, team, life-cycle, planning, project work, delivery, measurement, and uncertainty. In order to assess the structure and interrelationship between PMBOK 7th components, they are modeled, measured, and analyzed in this paper using the Social Network Analysis (SNA) tool. SNA is a technique that supports predicting the structure of an entity's group using graph theory and mathematical indicators. The results confirmed that all PMBOK 7th components are linked in different intensity levels. This research seeks to be a management tool for project managers and organizational analysts, giving quantitative support for effective organizational design and implementation.

Keywords
Project Management, Network Analysis, PMBOK 7, System Modeling, Social Network Analysis

1. Introduction
The Project Management Body of Knowledge (PMBOK) one of the most used guidelines for project management worldwide (Atencio et al. 2022). The 7th edition of PMBOK include a range of development methodologies, spanning from traditional predictive methods to more contemporary hybrid models. It introduces a specialized section focused on tailoring approaches and processes to suit specific project needs. Moreover, this edition expands its toolkit with the

addition of the "Models, Methods, and Artifacts" section, which places a greater focus on the tangible outcomes and deliverables of a project (PMI 2021).

A notable shift in this edition is the move away from the previously hierarchical structure of project management knowledge (Faraji et al. 2022). Instead, it adopts a more holistic principles-based approach. This approach is organized around eight distinct performance domains: stakeholders, team, life-cycle, planning, project work, delivery, measurement, and uncertainty. Each domain provides a comprehensive framework for understanding and managing various aspects of project management.
One of the challenges to apply the PMBOK is to address its wide variety of concepts and artifacts displayed along the text. All these components should work in an interrelated way to support the project management. In order to understand how PMBOK's components works together, the work of (Herrera & Atencio 2020) performs a Social Network Analysis (SNA) to model this guideline as a system. SNA is a methodology that utilizes graph theory and mathematical indicators to predict the structure of a group or entity (Atencio et al. 2023a).

This research aims to evaluate the structure and interrelationships of the PMBOK 7th edition's components, this paper employs Social Network Analysis (SNA). This analytical tool is instrumental in identifying how the components of the PMBOK 7th edition are interconnected, with varying degrees of intensity. The findings from this analysis indicate that all components of the PMBOK 7th edition are interconnected, though to different extents.

This research aims to serve as a valuable management tool for project managers and organizational analysts. By providing quantitative insights, it supports effective organizational design and implementation strategies. The application of SNA in this context offers a unique perspective on the PMBOK framework, potentially enhancing the understanding and application of its principles in the ever-evolving field of project management.

This paper is structured as follows: Section 2 comprises a background describing the SNA method and its related metrics. In addition, a PMBOK 7th edition summary is provided. In the Section 3 the development method is presented. The results and discussion are described in section 4 followed by the conclusion in Section 5.

2. Background

2.1 Network analysis

Social Network analysis (SNA) is a methodology introduced by Moreno (1960) that determine the conditions of social structures by investigating the relationships of a set of actors (Nooy et al. 2005). By using social network analysis is possible to visualize complex sets of relationships as maps and calculate precise measures of the size and density of the network as a whole and the position of each element within it (Hansen et al. 2020).

Based on the graph theory, social network consist of a finite set or sets of actors (nodes) that are connected by one or more type of relations (ties) (Wasserman & Faust 1994).

Nodes also known as actors, vertices, entities or items. Represent structures, organizations, content or even physical or virtual locations having attribute data that can add insight to the analysis and visualization (Hansen et al. 2020). The nodes are the points where information entry or exists.

Relations also known as links, ties, connections and relationships. Connect two nodes together and can represent different types of relationships like proximity, collaborations, kinship, friendship, trade partnerships, citations, investments, hyperlinking, transactions, and shared attributes (Hansen et al 2020). Relations represent the information flow inside the network.

SNA is supported by network analysis metrics allow to analyze the patters of connection, creating basis on which to compare networks, track networks over time and determine the relative position of individuals and clusters within a network (Hansen et al. 2020). These metrics can be divided into two groups: Aggregate network metrics presented on and Table 1 (Cherven 2013; Wasserman & Faust 1994) and Vertex-specific network metrics presented on Table 2. (Cherven 2015).

Table 1. Aggregate network metrics

Metric	Description

Network density	Count of the number of relationships observed in the network divided by the total number of possible relationships that could be present. It is used as a measure of cohesion.
Average degree	Average number of unweighted connections across a network.
Network diameter	The largest geodesic distance between any pair of nodes in a graph. Represents the largest eccentricity of any node.
Average path length	Represents the average distance between two nodes.

Table 2. Vertex-specific network metrics

Metric	**Description**
Indegree	This measure tells us how likely other nodes are to seek out a single node, whatever the attribute that makes this member an attractive target for others
Outdegree	Defined as connections flowing from a selected node to a range of other network members
Weighted indegree and outdegree	The degree is related to the sum of weights when analyzing weighted networks and labelled node strength, so the weighted degree and the weighted in- and out-degree were calculated
Eccentricity	Refers to the number of steps required for an individual node to cross the network. The diameter of the graph limits this number
Closeness centrality	This metric represents an interesting case, wherein the selected node might be poorly connected in a direct sense yet is still highly influential due to the proximity of well-connected neighbors
Betweenness centrality	Betweenness centrality corresponds to the level at which any given node serves as a bridge connecting other nodes
Clustering	Provides the ability to measure the level at which the nodes are grouped, as opposed to being equally or randomly connected across the network

2.2 PMBOK 7th overview

The 2021 release of the PMBOK's seventh edition marked a significant shift from its predecessors. Unlike the first six editions, which adopted a prescriptive approach, delineating project management into knowledge areas and processes, the latest edition embraces a principle-based methodology (Atencio et al. 2023b). This new approach is less directive and does not invalidate the previous versions. Instead, it suggests that both the older and newer guidelines can be effectively integrated. This compatibility between the sixth and seventh versions is further corroborated by Faraji et al. (Faraji et al. 2022), who highlight the complementary aspects of these editions.

The structure of the PMBOK 7th edition is outlined in schema presented in Figure 1. According to this figure, the PMBOK 7th is categorized into two main sections. The first section, the standard of project management, outlines the principles guiding project professionals and stakeholders. It includes the value delivery system, which encompasses organizational and strategic project elements like project concepts, portfolios, programs, products, and business operations (PMI 2021).

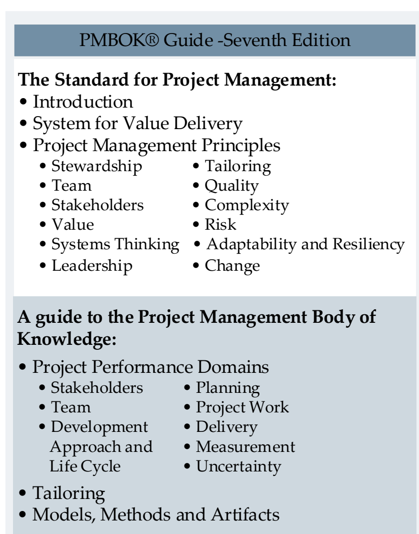

Figure 1. PMBOK7® structure (Adapted from: PMI 2021)

The second section, the guide to the PM body of knowledge, details essential project management functions aligned with different roles. These functions are organized across eight project performance domains, which are customized based on project requirements (PMI 2021). Each domain specifies a set of expected outcomes.

3. Development method

In order to provide a tool that supports construction SMEs during their process assessment and optimization, this research proposes a graph model that uses the PMBOK7 as guide standard given that it is considered the most popular project management standard (Werewka 2018) and one of the de facto standards for project management (Grau 2013). Moreover, the application and adaptation of this standard regarding the specific characteristics of the construction industry have already been studied and presented by Faraji et al. (2022).

To develop the above mentioned artifact, this research applied the method described in Figure 2. Which is divided into two stages: Stage (1) identification and modeling of PMBOK7 concepts and Stage (2) Graph model assessment.

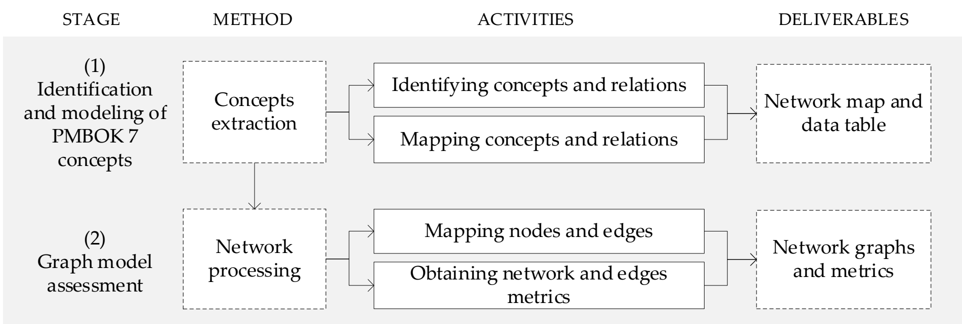

Figure 2. Project Management graph model methodology

Firstly, the PMBOK7 concepts are identified during Stage 1. This process is performed by reading and extracting the main concepts and relations between them. Then, these elements are mapped using the Kumu.io© editor for systems modelling which allows to export the graphic model into a data table, that will be the input for stage 2.

During Stage 2, the Network Analysis (NA) technique is applied. In this stage the previous data table is imported and processed using Gephi© software for NA obtaining the fundamental components: nodes and edges. Then, the graphical network is analyzed through the metrics presented in Table 1: Aggregate network metrics and Table 2: Vertex-specific network metrics, with the purpose to explain the relationship between the PMBOK7 components through mathematical indicators.

Finally, the outputs of this phase will be used as consultancy tools to evaluate the company's processes according to the PMI framework.

4. Results and Discussion

The following section present the results of this research based on the stages, methods, activities and deliverables presented in Figure 2.

4.1 PMBOK7 features extraction and modeling

As indicated in the previous section the main concepts and relationships of the PMBOK7 were obtained by reading and mapping into the model editor the concepts, following the structure of the book as presented in Figure 1.

With the purpose to make the model clearer and readable to the user, the concepts were modeled as elements, that contain a short description of the concept and a category from Table 3: Components' categories and Sub-Categories.

Table 3. Components' categories and Sub-Categories

Category	Sub - Category
Domain Components	Stakeholder domain components
	Team domain components
	Life cycle domain components
	Planning domain components
	Project work domain components
	Delivery domain components
	Measuring performance domain components
	Uncertainty domain components
Tailoring Components	Tailoring components
Models	Situational Leadership models
	Communication Models
	Motivation models
	Change models
	Complexity models
	Project team development models
	Other models
Methods	Data gathering and analysis methods
	Estimating methods
	Meetings and events
	Other methods
Artifacts	Strategy artifacts
	Logs and registers
	Plans
	Hierarchy charts
	Baselines
	Visual data and information
	Reports
	Agreements
	Other artifacts
Project components	Aspects of a project
	Project factors
	Life cycle phases
Project management components	Actions
	Activities
	Metrics
	Principles
	Communication components
	Documents
	Functions
	Resources
	Roles
	Skills
	Stakeholder aspects
	Value delivery components
	Variables

Then, the relationships were modeled as *connections* classified according to the categories presented in Table 4.

Table 4. Types of relationships

Types of relationships					
Applied to	Contains	Impacts	Interacts	Hierarchy	Results in
Applies	Encompasses	Includes	Is an input	Related to	Tailor
Based on	Establish	Indicates	Is an output	Requires	Uses

Resulting in the model shown in Figure 3 is composed by 599 components and 1346 connections, that represents the interactions between the 12 project management principles, 8 domain components, 22 models, 60 methods and 76 artifacts that can be used to properly manage projects.

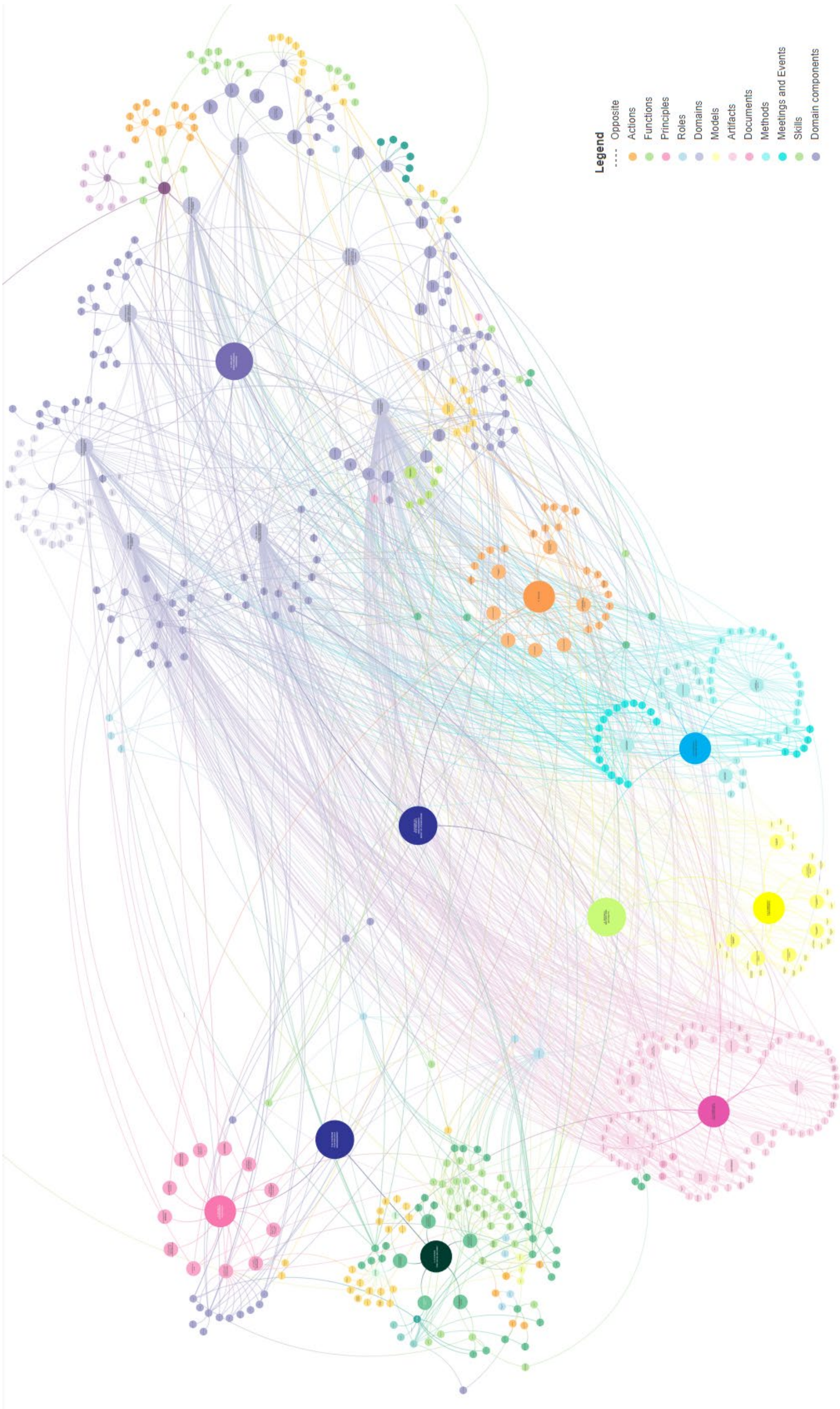

Figure 3. Resulting model using Kumu.io

4.2 Graph model assessment

After completing the modeling process presented above, all the concepts and their relationships were exported in a data table from Kumu.io and imported into Gephi for the Social Network Analysis, resulting in Figure 4.

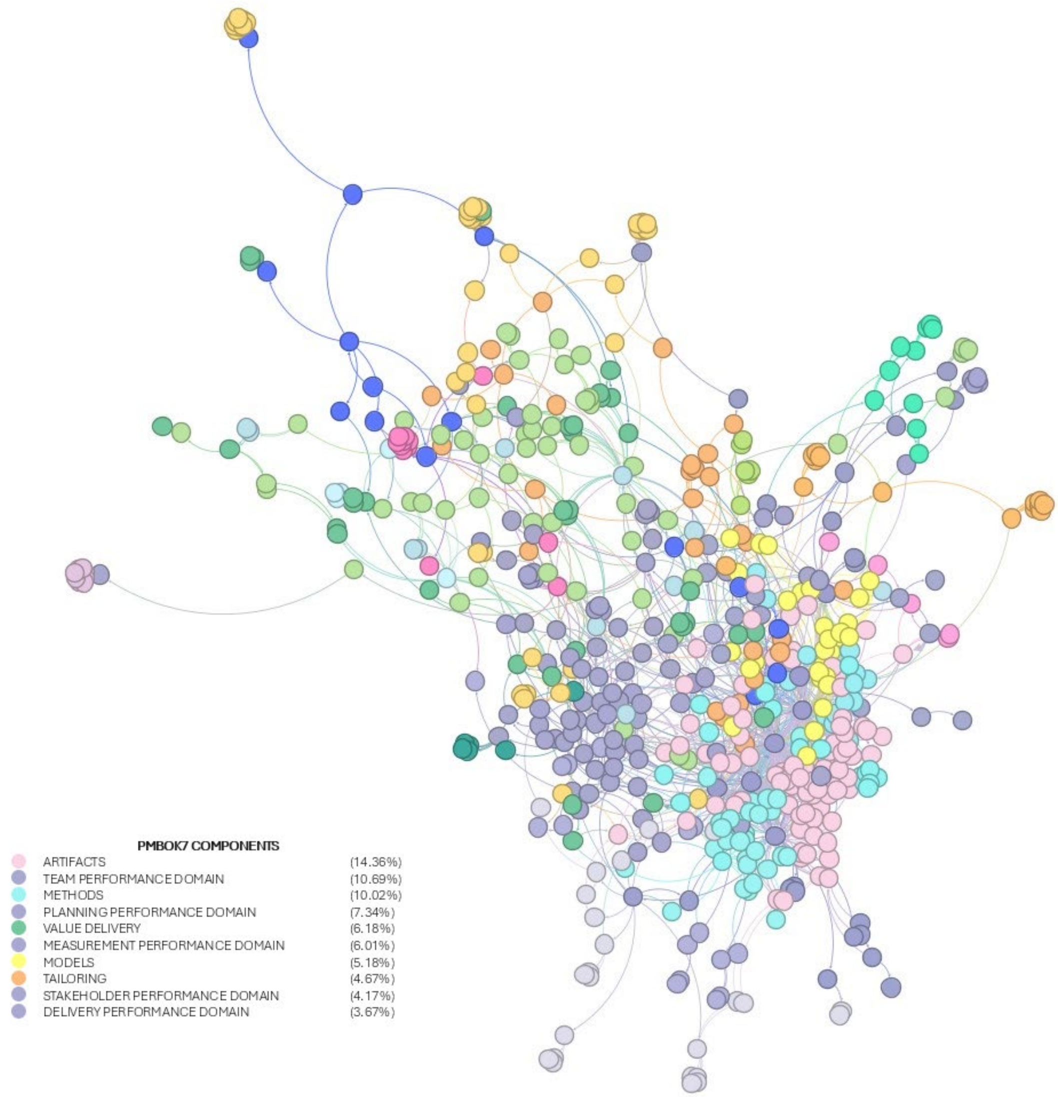

Figure 4. Graph with PMBOK7 concepts and their relationships

From Figure 4 can be identified that Artifacts play and important role in the PMBOK7 representing the 14.36% of concepts identified, followed by Team Performance Domain (10.69%), Methods (10.02%) and Planning Performance Domain (7.34%).

Moreover, the graph shows that Artifacts, Domains, Methods and Models play a central role in the network, interacting together as whole. This shows that PMBOK7 concepts act as a system, and this can be confirmed by the metric “Connected components” with a value equal to 1, which shows that all concepts make an interconnected block as shown in Figure 5.

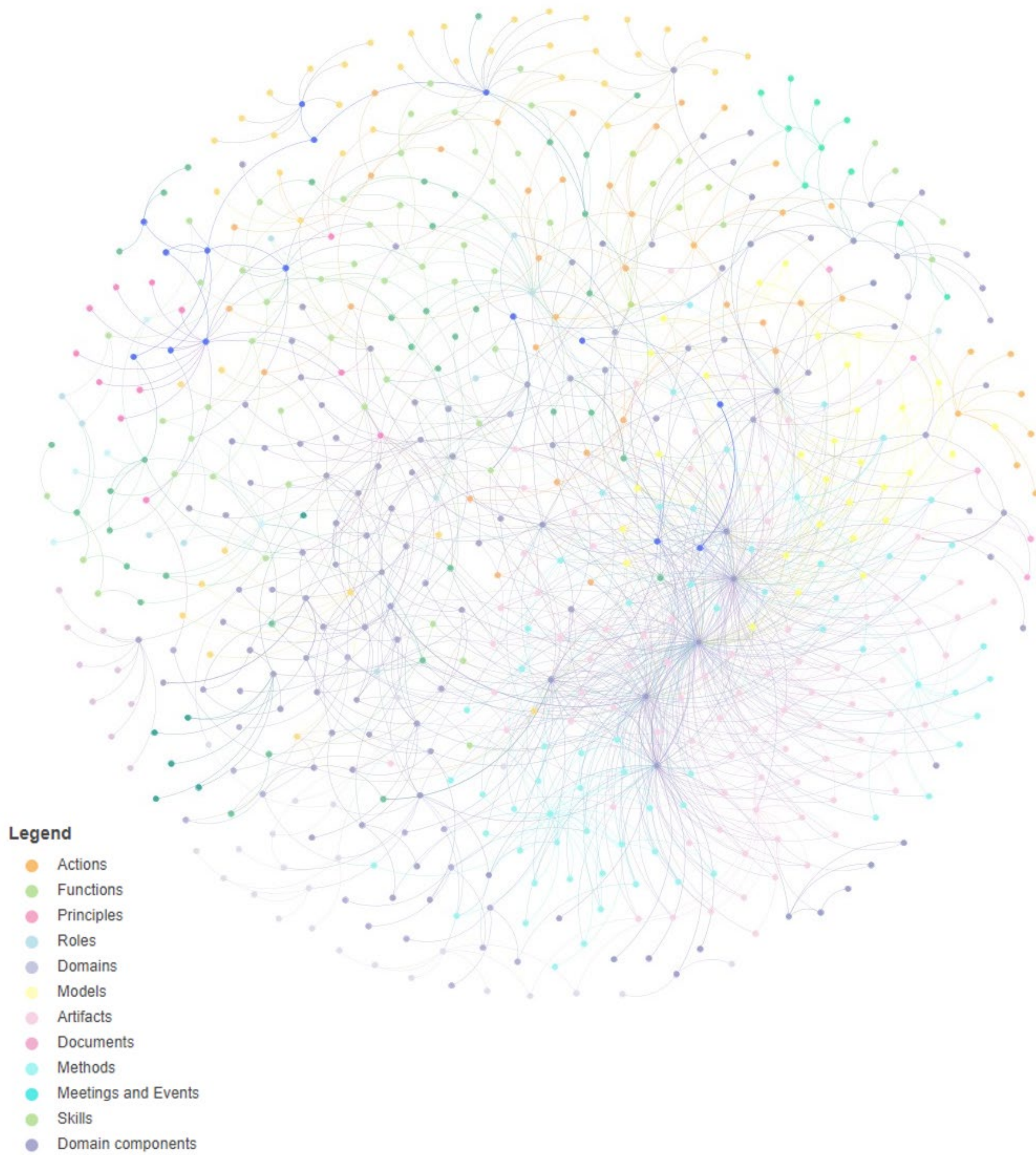

Figure 5. PMBOK7 concepts interaction

The node size is related to the degree (the connections in and out of each node), for this model the values vary from 1 to 138. Being the Planning performance domain the one with the highest number of connections (138), confirming that the Planning Performance domain plays and important role in the project management process. It is followed by Project work performance domain (110) and Delivery performance domain (77).

Moreover, the network can be analyzed regarding its NA metrics as follows:

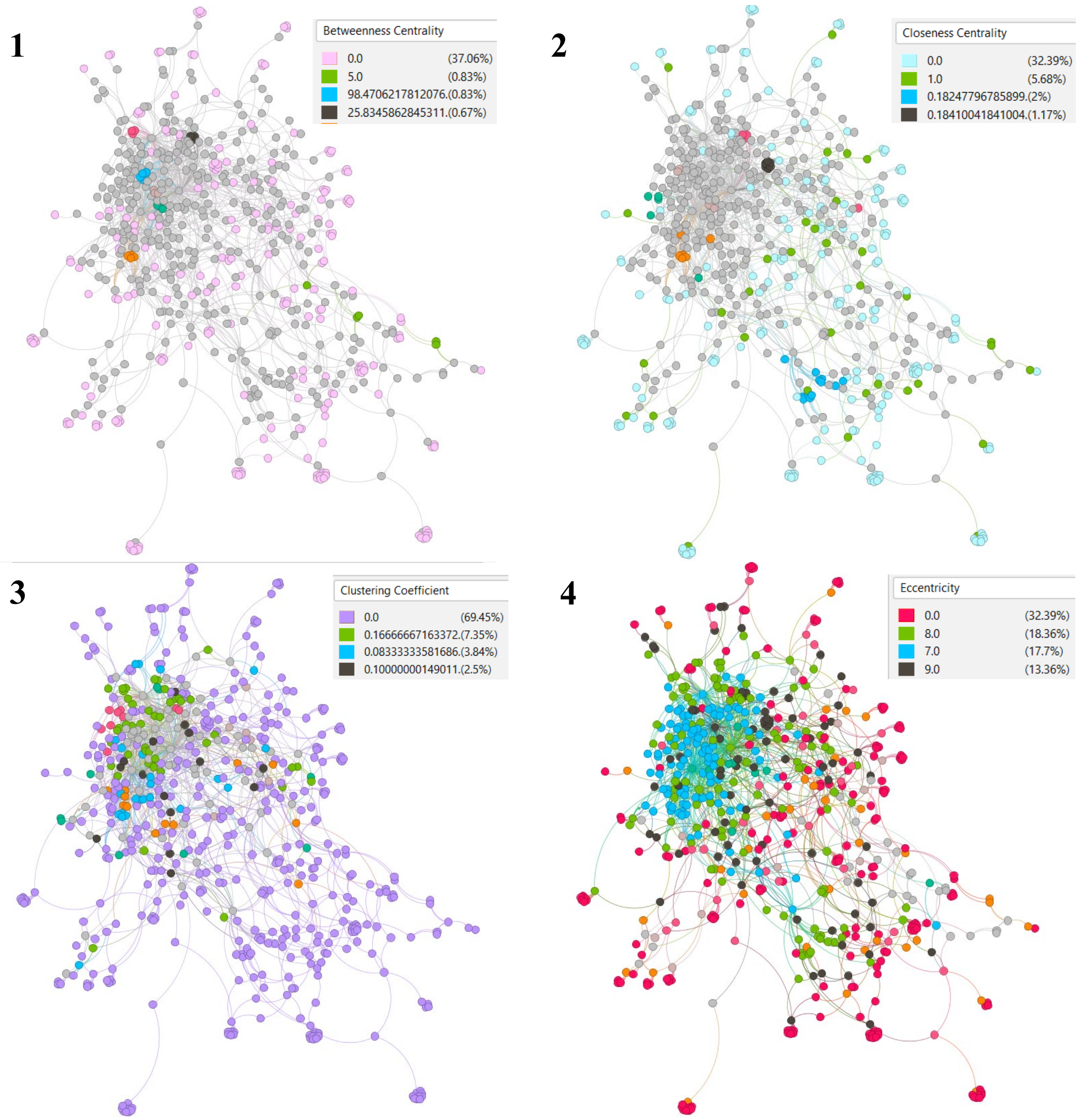

Figure 6. Networks metrics obtained and their graphic representation

Figure 6 shows the metrics obtained and a graphic representation for betweenness centrality (1), closeness centrality (2), clustering coefficient (3) and eccentricity (4).

Regarding Figure 6 (1), it can be observed that 37.06% have a betweenness centrality equal to zero. This mean that those nodes do not serve as a bridge for other nodes to connect others. This is caused by the modelling method used, where the nodes are mainly deployed in the form of branches that open up into class relations and subclasses as can be observed in Figure 3.

Figure 6 (2), presents the closeness centrality metric and its graphic representation. This metric represents the sum of the shortest paths between a node and others. 32.39% of nodes have a zero value, which means the nodes relatively connected and only 5.68% of the nodes have a value of 1 (good level of connection), and the rest have values between zero and one.

Figure Figure 6 (3) presents the clustering coefficient where can be observed that 69.45% of nodes have a zero value, meaning low degree of clustering. Finally, Figure 6 (4), shows the Eccentricity metric which relates to the minimum steps required for any node with a maximum value equal to the network's diameter (value equal to 13). 32.39% have a value equal to zero.

In order to conclude, Table 5 summarizes the metrics obtained for the network. The value equal to 0.004 indicates that the nodes are now cohesive and it can be identified dispersion among them. The average degree with value equal to 2.19 reflects the average links between each network's node. The network's diameter equal to 13 means that one concept is thirteen nodes of distance to meet with others as maximum distance. The average path length indicates that each node requires on average 5.116 paths to meet the other node. Modularity indicates the level of connections between nodes conforming to a cluster. Considering a maximum value of 1, the value of 0,547 shows a medium density of connections into a cluster.

Table 5. SNA metrics

Metric	Value
Density	0.004
Average degree	2.19
Diameter	13
Average path length	5.116
Modularity	0.547
Clustering coefficient	0.046

5. Conclusion

The proposed model allows to understand and have a clear vision of the project management process inside the company and its relationships.

From the network analysis performed during the creation of Artifact 1: PMBOK graph model was possible to identify that the planning performance domain plays an important role in project management, given that it has 138 connections, demonstrating great influence on the other PM components. As a result, this research suggest to pay special attention to the planning processes during the modelling and assessment stages of the framework.

Moreover, the network analysis confirmed that PMBOK7 concepts act as a system, since the metric "Connected components" have value equal to 1, which shows that all concepts make an interconnected block. This fact highlights that project management process are interconnected confirm that is crucial to a have systemic view of the company's process.

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Biographies

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