Graph Analytics for User Satisfaction Analysis in Service Systems: A Blue-Green Economy Perspective

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Abstract. This study analyzes student satisfaction with a university system by employing graph theory to visualize and explore patterns in their responses. By constructing a graph where each student represents a node, and connections are formed based on the similarity of their satisfaction ratings, we reveal key insights into the system's effectiveness. The analysis demonstrates a fully connected graph, indicating a high level of consistency across the student population in terms of their overall satisfaction. Degree centrality was used to identify students whose satisfaction levels most closely reflect the general consensus. The results highlight that the system is well-regarded across various dimensions, such as system quality, responsiveness, and flexibility. The most central students, representing the majority viewpoint, are indicative of the system's successful design and performance. This comprehensive analysis concludes that the system meets the expectations of a diverse student body, providing a positive and cohesive user experience. Future improvements should aim to maintain this consistency while addressing subtle differences in satisfaction among smaller student subgroups.

Keywords: Satisfaction, Graph Theory, Degree Centrality, Blue-Green Economy, User Experience.

1 Introduction

As global challenges such as climate change, resource depletion, and environmental degradation intensify, there is growing recognition of the need for economic systems that prioritize sustainability. The concept of the blue-green economy has emerged as a transformative model that integrates environmental sustainability (green economy) with the responsible use of marine and aquatic resources (blue economy) to promote balanced economic growth. In this context, a study was conducted to analyze community empowerment strategies and the blue-green economy concepts in relation to the income of the Thousand Islands' residents. While the topic is highly relevant, particularly with the growing global interest in sustainable economic practices, the text could be more concise and better structured. It effectively outlines the research variables, methodology, and key findings, but the language is somewhat repetitive, and the results section is unclear in places, particularly regarding the impact of community empowerment strategies. The use of advanced statistical tools such as

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Smart PLS and SPSS adds rigor to the research. However, the overview lacks sufficient background on the blue and green economy concepts, and clearer explanations would enhance the reader's understanding. Overall, the piece could benefit from clearer organization and a more focused presentation of results [1].

This study examines the impact of customer satisfaction and service quality on customer loyalty at Wedangan Moh Yamin, a food business. As consumers increasingly prioritize not just product quality but also cleanliness, the research focuses on how these factors influence loyalty. With a quantitative approach, the study involved 100 respondents, using non-probability sampling and purposive side methods. Data was collected via a Google Forms questionnaire and analyzed using SPSS 25.0 for respondent characteristics and SMARTPLS 3.0 for deeper analysis. The results indicate that customer satisfaction positively influences both service quality and customer loyalty. The study suggests that by focusing on service quality and customer satisfaction, businesses can foster stronger relationships with their customers, leading to increased loyalty and, ultimately, business growth. The recommendation for entrepreneurs is to prioritize service quality to ensure customer satisfaction and loyalty[2].

Customer loyalty is significantly affected by the quality of service. Customers who experience excellent service are more likely to become loyal and dedicated. By prioritizing high-quality service and customer satisfaction, companies can establish strong, long-lasting relationships with their customers. This, in turn, helps retain existing customers, reduces churn, and enhances overall loyalty. The findings of this study differ from Rahmadiane et al. (2022), who claim that "there is no effect between service quality and customer loyalty"[3]

The systematic computational analysis of data or statistics, often known as analytics, is another concern that arises in data management. Analytics identifies, evaluates, and conveys significant patterns in data. Utilizing data trends is essential for making more informed decisions. The way analytics interprets data can differ depending on the approach. Analytics may be based on either graph data or tabular/relational data[4]. In Graph Analytics, queries are executed using the connections between entities[5]. Based Vicknair et al.,a graph database performs queries faster than a relational database[6].

The research gap in this paper lies in the use of graph theory in analyzing user satisfaction, especially in the context of university service systems. Although there has been a lot of research on user satisfaction and system quality, this research highlights the lack of graph-based approaches in visualizing satisfaction patterns. This is different from previous studies which relied more on conventional statistical analysis. This research fills the gap by using degree centrality analysis to identify students whose satisfaction best aligns with the general consensus, providing new insight into the uniformity of user satisfaction.

2 Related Work

Research on user satisfaction by Machmud Rizan (2018) explains that McGill et al. (2003) who tested the DeLone and McLean Model (1992) found that perceptions of information quality and system quality were important factors that influenced user satisfaction. In addition, user satisfaction is proven to have a significant influence on usage intentions and perceived individual impact. Meanwhile, a study conducted by Livari (2005) also found that perceptions of system and information quality played an important role in increasing user satisfaction, but did not have a significant impact on the frequency of system use. User satisfaction also acts as a major predictor of individual impact[7]

Meanwhile, research conducted by Lidya et al (2021) tested the success model of the DeLone and McLean information system on the Audit Application System (SiAP) at the BPK RI North Sulawesi Province Representative, with a focus on auditors who use the system. This research uses quantitative methods and data analysis through the Partial Least Square Structural Equation Model (PLS-SEM) with questionnaires distributed to 60 auditors. The results show that net benefits are influenced by user satisfaction, which is only influenced by information quality, while usage is influenced by system and service quality[8].

The use of graph theory has been applied here, but can be expanded more deeply with concepts such as centrality, betweenness, and clustering coefficient to better understand complex relationships between users. One of them is a paper written about graphs by Aulian (2020)[9]. Research on graphs is represented by Ristantya et al (2020) who conducted a study of the concept of Social Network Analysis (SNA), which in the concept of this method can produce insights obtained through basic analysis techniques, such as community detection, which is useful for drawing conclusions and knowledge discovery activities[10].

This research on the study of Blue-Green Economy theory is in the context of adding economic theory to the environment and natural resources, which will strengthen discussions regarding system sustainability in supporting social and environmental goals. According to Sofyaningrum et al (2023), green economy and blue economy are the best solutions for community activities. Improving the community's economy while still paying attention to environmental sustainability makes green economy and blue economy important things to immediately implement as a form of sustainable development[11].

3 Research Method

The research methodology for this paper will focus on utilizing graph-based analysis to evaluate user satisfaction patterns in management services. The data used to carry out this analysis was taken from the Kaggle Open Dataset[12]. Figure 1 below shows the research stages carried out :

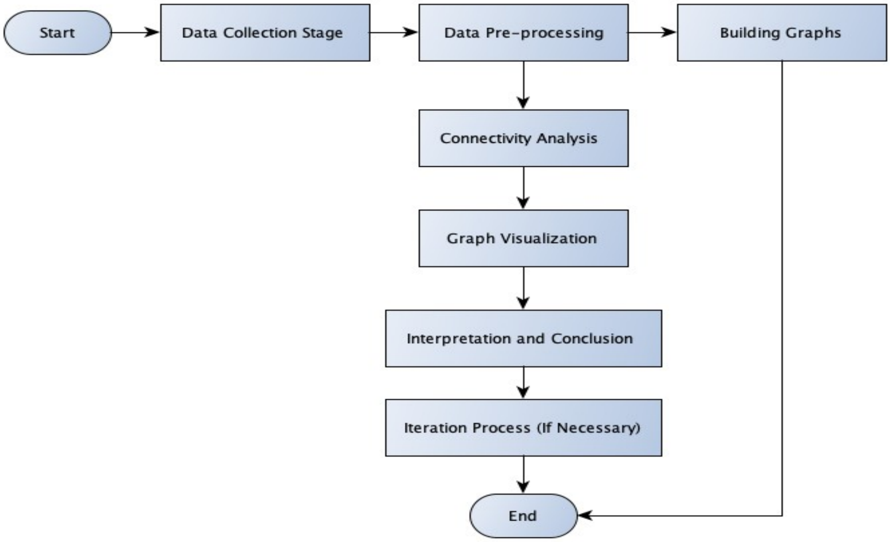

Fig. 1. Research Steps

3.1 Graph Analysis Results

The following is the graph analysis process using the Python code :

```
 # Install dependencies
pip install networkx pandas matplotlib
# Import the necessary libraries
import pandas as pd
import networkx as nx
import matplotlib.pyplot as plt
# Load dataset from survei.csv
#  Make  sure  the  survey.csv  file  has  been  uploaded  to
Google Colab
df = pd.read_csv('Survei2.csv')
# Display the dataset to verify
df.head()
# Initialize an empty graph
G = nx.Graph()
# Add nodes based on user name data
for index, row in df.iterrows():
    user_id = index  # Gunakan index sebagai ID
    G.add_node(user_id,            jurusan=row['Jurusan'],
semester=row['Semester'],
               kualitas_sistem=row['Kualitas    Sistem'],
penggunaan=row['Penggunaan'],
               responsivitas=row['Responsivitas'],
fleksibilitas=row['Fleksibilitas'],
```

```
                informasi=row['Informasi'],
kepuasan=row['Kepuasan'],
                klasifikasi=row['Klasifikasi Kepuasan'])

# Add sides between users if they have the same rating in
all categories
for i in range(len(df)):
    for j in range(i + 1, len(df)):
        similarity  =  (df.iloc[i,  3:]  ==  df.iloc[j,
3:]).sum()
# Comparing attributes
if similarity >= 5:  # Threshold minimal kesamaan atribut
            G.add_edge(i, j, weight=similarity)
# Using ID as edge
#  Display  graph  information  before  clearing  remote
vertices
print(f"Number     of     nodes     before     cleaning:
{G.number_of_nodes()}")
print(f"Number     of     edges     before     cleaning:
{G.number_of_edges()}")
# Identify remote vertices (nodes with degree 0)
isolated_nodes   =   [node   for   node,   degree   in
dict(G.degree()).items() if degree == 0]
# Remove remote vertices from the graph
G.remove_nodes_from(isolated_nodes)
#  Display  graph  information  after  clearing  remote
vertices
print(f"Number     of     nodes     after     cleaning:
{G.number_of_nodes()}")
print(f"Number     of     edges     after     cleaning:
{G.number_of_edges()}")
# Plot graf
pos = nx.spring_layout(G)  # Layout untuk graf
plt.figure(figsize=(16, 12))
nx.draw(G,   pos,   with_labels=True,   node_size=100,
node_color='red', font_size=6, font_weight='regular')
# Describes the side weights
labels = nx.get_edge_attributes(G, 'weight')
nx.draw_networkx_edge_labels(G, pos, edge_labels=labels)
plt.title("User  Satisfaction  Graph  (After  Cleaning
Isolated Nodes)")
plt.show()
# Graph connectivity analysis
connected_components = list(nx.connected_components(G))
print(f"Connected Components: {connected_components}")
# Check whether the graph is fully connected
is_connected = nx.is_connected(G)
print(f"Is the graph connected? {is_connected}")
```

```
# Centrality (measures which nodes are most connected)
degree_centrality = nx.degree_centrality(G)
print("Degree Centrality:")
for user, centrality in degree_centrality.items():
    print(f"{user}: {centrality:.2f}")
# Analyze the most common satisfactions (nodes connected
to many people)
most_connected_user      =      max(degree_centrality,
key=degree_centrality.get)
print(f"The   most   connected   user   (most   similar
satisfaction): {most_connected_user}")
```

3.2 Explanation of Graph Analysis

Fig. 2. Graph plot of satisfaction analysis

From the graph analysis carried out, it was linked to the level of satisfaction based on the dataset used.

Dataset Context.
The dataset used appears to contain information about student satisfaction with various aspects of the system, such as:

- System Quality (Strongly Agree, Agree)
- Use
- Responsiveness
- Flexibility
- Information
- Satisfaction
- Satisfaction Classification (Satisfied)

Each row in the dataset represents an individual student with attributes related to their perception of the system used, and the Satisfaction Classification states whether the student is satisfied.

Graph Analysis in the Context of Satisfaction.
This graph is built based on the similarity of levels of satisfaction and perception of system attributes. Each node in the graph represents a student, and the connection (edge) between two nodes indicates that the student has a similar level of satisfaction and perception of various aspects of the system. In other words, the more similar two students' answers are, the more likely they are to be connected in the graph.

The result stating that there is one large connected component (Connected Components) means that all students in this dataset, although they may have different views on some aspects, ultimately have enough in common that they are connected to each other in this satisfaction network. This shows that student satisfaction levels are relatively consistent across the dataset, with no group of students being completely isolated or differing to the extreme in their views.

The fact that this graph is fully connected (True) indicates that no group of students is significantly isolated from the others. They all had fairly similar views, especially in terms of satisfaction with the system, reflecting consistency in students' perceptions of the quality of the system and its attributes. Degree centrality measures the number of relationships a student has in the network. In this context, degree centrality reflects how similar one student's level of satisfaction is to other students.

Nodes with high degree centrality (0.59), such as nodes 1, 4, 7, 8, 16, are students who have a lot in common with other students in terms of satisfaction and perception of the system. They can be considered as students with the most general level of satisfaction or representative of the views of the majority of other students. Nodes with low degree centrality, such as nodes 3, 20, 43, indicate students who may have views that are more unique or slightly different compared to other students, although they remain connected to the satisfaction network.

Node 1, which is the most connected node, represents students who have views that are most similar to most other students. This suggests that this level of student satisfaction may reflect the majority or general opinion among all students. In other words, this student has a very high level of satisfaction with many other students in the dataset.

Overall Interpretation of Graph Analysis in the Context of Student Satisfaction. This graph illustrates that the level of student satisfaction with the system is highly connected and consistent across the dataset. Most students had similar perceptions of various aspects of the system such as quality, responsiveness, flexibility, and information provided. There are some students who may have more specific or unique views, but overall, no student is truly isolated from the rest of the group in terms of satisfaction. The student with the highest connectedness (Node 1) represents the most general level of satisfaction and may exemplify the majority view of the system.

Overall, this graph analysis helps us see that students' perceptions of the system are quite homogeneous, which may indicate that the system provides a consistent experience for the majority of its users, especially in terms of satisfaction.

4 Conclusion

The analysis of the satisfaction data using graph theory reveals important insights into the overall perception of students regarding the system. By representing each student as a node and connecting them based on similarities in their responses, it is evident that the majority of students share a common perspective on the system's performance.

The fully connected nature of the graph, where every student is linked either directly or indirectly, indicates that there is no isolated group with vastly different opinions about the system. This implies a high level of consistency in the students' satisfaction levels, with all students being somewhat aligned in their views. The presence of a large connected component reflects that the system provides a consistent user experience across different student demographics and academic backgrounds.

The degree centrality measure highlights certain students whose satisfaction closely mirrors the majority, particularly those with high centrality values. These students are representative of the general consensus, showing that their perception of the system is closely aligned with that of others. Meanwhile, students with lower centrality values may have slightly differing opinions but are still part of the overall satisfaction network.

The most connected student (Node 1) has a satisfaction profile that reflects the opinions of many other students, suggesting that their experience is emblematic of the broader student population. This indicates that the system's overall quality, in terms of responsiveness, flexibility, and the information provided, is perceived positively by the majority of students.

In conclusion, the analysis demonstrates that student satisfaction is both widespread and interconnected, with no significant discrepancies between different users. The consistency in the satisfaction ratings suggests that the system is well-designed to meet the needs of a diverse student body. Future efforts to improve the system should continue focusing on maintaining this consistency while addressing the subtle differences that exist among smaller groups of students to enhance overall satisfaction even further.

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