Software Requirement Specifications

<Visualization of Collaborative Learning Networks Using igraph>

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Meeting Details

Sr No	Details	Date	Supervisor Signature
1	Initial project discussion and topic finalization	15-10-2025	
2	SRS requirements discussion and feedback	5-11-2025	

Summary

This document presents the development of a system titled **"Visualization of Collaborative Learning Networks Using igraph."** The project addresses the growing need to understand student interactions in modern digital learning environments. Students frequently communicate and collaborate through online platforms, discussion forums, group chats, and learning management systems, generating large amounts of interaction data. However, without proper analytical tools, educators face challenges in interpreting these complex networks.

The system developed in this project transforms student interaction data into **network graphs**, where nodes represent students and edges represent interactions. By applying **social network analysis metrics** such as degree centrality, betweenness centrality, eigenvector centrality, and community detection algorithms, the system identifies influential learners, isolated participants, and natural subgroups within the class. The system provides both **static and interactive visualizations**, allowing educators and researchers to explore collaboration patterns effectively.

The findings demonstrate that network visualization can significantly aid in monitoring student engagement, improving group formation, and facilitating data-driven decisions in collaborative learning contexts. The requirements for this system included data preprocessing, graph construction, metric computation, community detection, visualization generation, and report export functionalities. Overall, this project provides a valuable tool for educational data analysis and enhances the understanding of collaborative learning dynamics.

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1. Introduction

Collaborative learning plays a major role in modern education systems, enabling students to share knowledge, solve problems collectively, and enhance understanding through interaction. With the shift toward digital learning environments, large volumes of student interaction data are generated through online platforms, discussion forums, group chats, and learning management systems. However, without proper tools, educators cannot easily interpret these complex networks of interactions.

This project focuses on **visualizing collaborative learning networks** using **igraph**, a powerful graph-analysis library. The system identifies collaboration patterns, central participants, isolated learners, and community structures. This visualization helps educators and researchers better understand student engagement and improve group-based learning strategies.

1.1. Purpose

The purpose of this project is to:

● Provide a system that **visualizes relationships and interactions** among students.

● Help educators understand **group formation**, **student engagement**, and **collaboration flow**.

● Use **network analysis metrics** (degree, betweenness, eigenvector centrality) to identify key learners.

● Provide both **static** and **interactive** visualizations for deeper exploration.

● Support decision-making in teaching, peer assessment, and group management.

1.2. Scope

The scope of this project includes:

- Collecting interaction data (e.g., chat logs, participation records, group work).
- Preprocessing and converting the raw data into an edge list suitable for graph creation.
- Building and analyzing a collaborative learning network using igraph.
- Generating meaningful insights through centrality metrics and community detection.
- Visualizing the network using **force-directed layouts**.
- Creating simple **interactive dashboards** (optional).

The project does **not** include predictive analytics, automated grading, or AI-based recommendation systems unless extended in future work.

1.3. Product Perspective

This system fits within the broader category of **Learning Analytics Systems**, where the goal is to transform educational data into actionable insights. It acts as:

- A standalone analytics tool for teachers and researchers.
- A visualization module that can integrate with LMS systems (like Moodle, Google Classroom).
- A diagnostic tool for identifying collaboration issues in group-based learning environments.

It complements existing educational tools by adding **graph-based insight**, which traditional dashboards fail to provide.

1.4. User Characteristics

The intended users include:

Teachers / Instructors

- Require an overview of collaboration patterns.
- Need to identify inactive or isolated students.

Students

- Can view their own engagement level (optional module).
- Understand how they connect within the learning network.

Researchers

- Analyze group behavior, knowledge flow, and learning patterns.
- Use exported graphs for academic research.

Administrators

- Monitor overall classroom activity and improve course design.

Users may have **basic computer knowledge** but do not require technical expertise.

1.5. Similar apps and systems/Literature Review

Several tools and studies support the idea of analyzing collaborative learning networks:

Existing Tools

- **Gephi:** A desktop graph-analysis tool but not automated for educational data.
- **Cytoscape:** Powerful, mainly biomedical network visualization.
- **NodeXL:** Excel-based SNA tool with limited flexibility.
- **Moodle Analytics:** Provides activity statistics but not full network visualization.

Literature Review Highlights

- Social Network Analysis (SNA) has been widely used to study student behaviors.
- Studies show that high centrality often correlates with academic performance.
- Community detection helps identify natural study groups.
- Graph-based visualization improves teacher interventions.
- igraph is often used due to its high performance, scalability, and visualization quality.

This project fills the gap by developing an **easy-to-use, customizable, and education-focused SNA visualization system**.

1.6. Proposed Technologies

Component	Technology
Programming Language	Python or R
Graph Library	**igraph**
Interactive Visualization	pyvis (Python) / visNetwork (R)
Front-End (optional)	Streamlit / Shiny
Data Storage	CSV / JSON
Code Editor	VS Code / RStudio
Visualization Layouts	Fruchterman–Reingold, Kamada–Kawai

2. Requirements

The system requirements define the functional and non-functional aspects necessary to build the **Collaborative Learning Network Visualization System** using igraph. These requirements ensure that the system meets user expectations, is reliable, and provides actionable insights from student interaction data.

2.1. Function Requirements

2.1.1 Sign Up (Only if your project includes a dashboard)

- The system shall allow users (teacher/researcher) to create an account.
- Users shall log in using email and password.
- User information shall be stored securely.

(If your project has no login system, we can remove this section.)

Core Functional Requirements

1. **Data Upload**
   - The system shall allow uploading an interaction dataset (CSV/Excel).
2. **Graph Construction**

    - The system shall convert uploaded data into nodes and edges.
    - The system shall assign weights to edges based on interaction frequency.
3. **Graph Analysis**
    - The system shall compute degree, betweenness, eigenvector centrality.
    - The system shall detect communities automatically.
4. **Graph Visualization**
    - The system shall generate static graphs.
    - The system shall produce interactive visualizations.
    - Users shall be able to zoom, explore, highlight nodes.
5. **Insights & Reports**
    - The system shall display collaboration metrics.
    - Users shall be able to export results (optional).

2.2. Non-Functional Requirements

Performance

- Must handle datasets up to 500–2,000 students.
- Graph rendering must complete within 2–5 seconds (for medium graphs).

Usability

- Interface must be simple and user-friendly.
- Users should understand controls without training.

Reliability

- System should handle incorrect/missing data gracefully.

Scalability

- Should support larger datasets by optimizing graph layouts.

Security (if login is included)

- Passwords must be encrypted.
- User data must remain private.

Portability

- Should run on Windows, macOS, and Linux.

3. Use Cases and Flow of Processes

Below is the main flow:

3.1 Data Upload and Graph Visualization (Use Case 1)

Actors: Teacher / Researcher
Preconditions: Dataset available
Flow:

1. User logs in (if login system exists).
2. User uploads interaction CSV.
3. System preprocesses data.
4. System constructs a graph using igraph.
5. System calculates centrality measures.
6. System detects communities.
7. System generates visualizations.
8. User views insights and exports reports.

Postconditions:
Graph visualization and metrics are displayed.

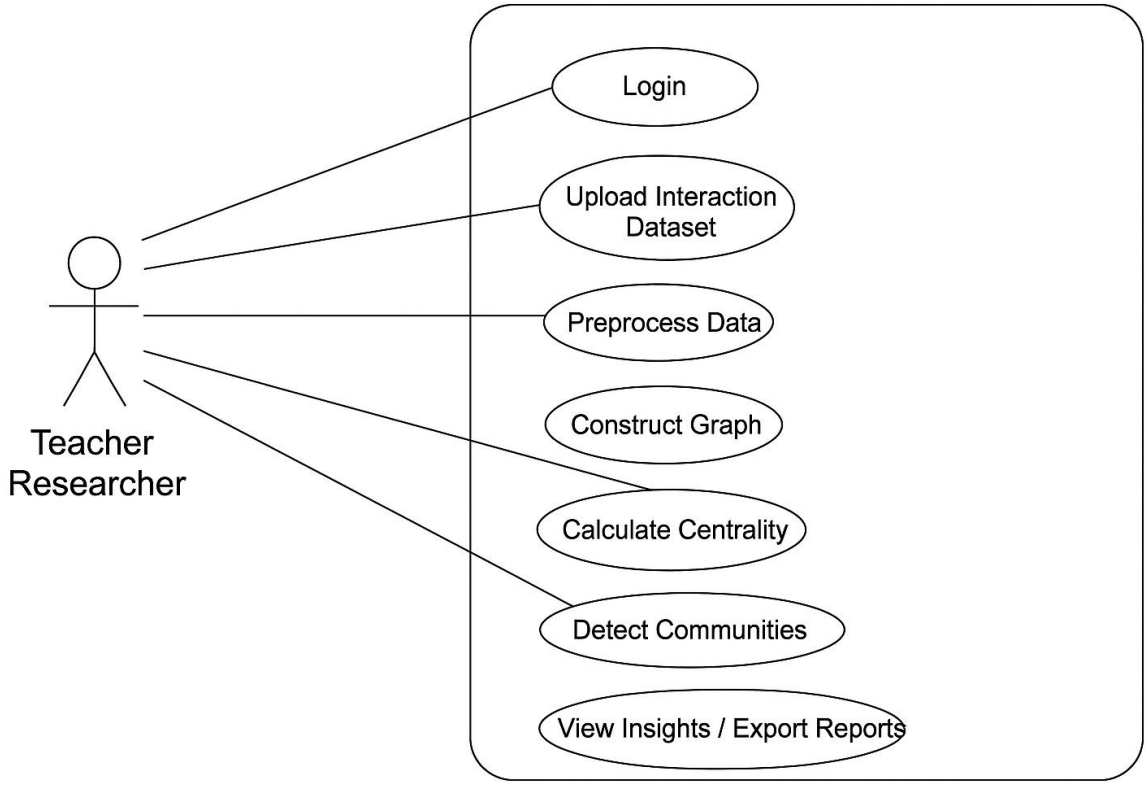

Figure1: Collaborative Learning Network Use Case Diagram

3.1. Use Case 1

Item	Description
Use Case Name	Generate Collaborative Learning Network
Actor	Teacher / Researcher
Description	User uploads dataset and the system generates a graph visualization using igraph.
Preconditions	Data file exists and is formatted correctly.
Basic Flow	1. Upload -> 2. Process -> 3. Build Graph -> 4. Analyze -> 5. Visualize
Alternate Flow	Invalid file → System shows error message.
Postconditions	Graph and metrics displayed, downloadable.

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4. References

You may include:

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