Final Infovis Project Report

(Course final project for INFOSCI 301 - Data Visualization and Information Aesthetics,
instructed by Prof. Luyao Zhang at Duke Kunshan University, Spring 2025.)

Title: "Global Student Mobility Dashboard: Visualizing International Education Flows and Economic Correlations"

Abstract:

This project investigates global trends in international student mobility by analyzing inbound and outbound flows from 2000 to 2022. Drawing on data from the UNESCO Institute for Statistics (UIS), the World Bank, and OECD, we visualize student migration across time and space and examine its correlation with macroeconomic indicators like GDP. Using interactive tools and map-based visualizations developed in Python (Plotly, Streamlit), we explore the uneven geography of educational exchange and identify emerging regional hubs. The project highlights patterns of mobility, access gaps, and economic drivers behind global student flows, contributing to SDG 4 on Quality Education.

1. Contribution to SDG 4: Quality Education

This project aligns with Sustainable Development Goal 4 by:

- Highlighting global disparities in access to international education opportunities.
- Encouraging data-driven awareness of educational migration and its link to economic development.
- Supporting equity conversations in higher education policies and student mobility strategies.

This project focused on visualizing access gaps, especially from low-income regions with limited outbound mobility, and the rise of new education hubs as part of global equity.

Figure1. Logos for SDG 4 ("Quality Education"), retrieved from https://sdgs.un.org/goals/goal13

2. Team Contribution Statement

- **Yiqing Wang**: Responsible for data acquisition, data visualization, and GitHub repository development.
- **Nemuulen Togtbaatar**: In charge of data cleaning, literature review, visualization improvements, and final web deployment.

3. Background & Motivation

In an increasingly interconnected world, access to quality education across borders has become not only a personal aspiration for many but also a critical driver of social mobility, economic development, and international collaboration. However, international education opportunities remain deeply uneven. While some countries serve as global magnets for talent, others struggle to send students abroad due to economic, infrastructural, or policy-related limitations.

Our project was motivated by a desire to better understand and visualize this imbalance. By mapping global student mobility flows, we aim to shed light on who is participating in the global education exchange—and who is being left behind. International education is not just an academic issue; it is a reflection of larger systemic inequalities shaped by economic power, regional politics, and institutional access.

By combining real-world data with thoughtful design strategies, our project makes visible the hidden geography of education opportunity, drawing attention to both the progress and the disparities that define global student mobility today.

4. Research Questions

1. Which countries are the largest senders and receivers of international students, and how does this correlate with their GDP?
2. How have student mobility patterns evolved over the past two decades, particularly in relation to economic changes, and what is the future direction?
3. Are there identifiable regional trends in student migration linked to economic indicators?

5. Application Scenarios

Our visualization and data analysis provide meaningful insights that can support multiple real-world applications. First, policymakers in international education and scholarship organizations can leverage these insights to identify which countries are most actively sending or receiving students, helping to better allocate resources or adjust visa and funding policies. Second, universities and ministries of education can use the findings to inform strategic planning, such as identifying underserved regions or anticipating future shifts in mobility demand. In addition, the visualizations can support digital platforms that help students explore mobility options by making trends in origin-destination flows more transparent. Finally, the data we've compiled can also serve as a foundation for comparative academic research on globalization, educational inequality, and cross-border knowledge exchange.

6. Methodology

This project integrates data from three main sources: the World Bank, UNESCO Institute for Statistics (UIS), and the OECD. Both data sources emphasize openness, quality, accessibility, interoperability, and transparency. The core variables include inbound and outbound international student counts (from UIS and OECD), GDP and education expenditure figures (from the World Bank), and origin-to-destination share matrices for 2022 (from the OECD's Education at a Glance dataset).

Data manipulation was conducted using Python's pandas library within Google Colab. We addressed issues such as missing values, inconsistent country naming conventions, and wide-to-long format transformations, so we manually fixed some errors. For visualization, we used Plotly due to its flexibility in creating interactive charts, and deployed the project via Streamlit to enable public access.

Our visual encoding strategies were carefully designed. We draw design inspiration from "Practices and Strategies in Responsive Thematic Map Design" (Schöttler, 2025) that highlights challenges in thematic map design, such as overlapping symbols, navigation difficulties, and loss of context, and suggests strategies like dynamic scaling and interactive features. Our project adapts these ideas to create accessible, responsive migration visualizations. Also, we have implemented the "Overview first, zoom and filter, then details-on-demand" idea (Munzner, 2014). We used dot marks with size encoding to represent student volumes, line thickness to indicate flow volume between countries, and distinct color coding—blue for inbound flows and pink for outbound—to create immediate visual differentiation. This color contrast was tested using https://www.color-blindness.com/coblis-color-blindness-simulator/ and was safe for most color-blindnesses. These color choices were guided by basic luminance contrast principles to enhance clarity. Interactivity played a key role: users can hover to explore tooltips, view animated time-series data from 2000 to 2021, and interact with thematic maps that scale responsively based on the viewport.

7. Results & Key Visual Outputs

A. Animated Map (2000–2021):

Between 2000 and 2021, international student migration patterns underwent significant transformations, reflecting broader trends in globalization, economic development, and educational access.

In 2000, the landscape of international education was relatively concentrated. A small group of developed countries — particularly those in Western Europe, North America, and Oceania — acted as the primary destinations for mobile students. Inbound flows were modest in scale and largely limited to traditional education hubs like France, Germany, the United Kingdom, Australia, and the United States. Meanwhile, outbound flows from developing countries were present but relatively limited, both in volume and in geographic reach.

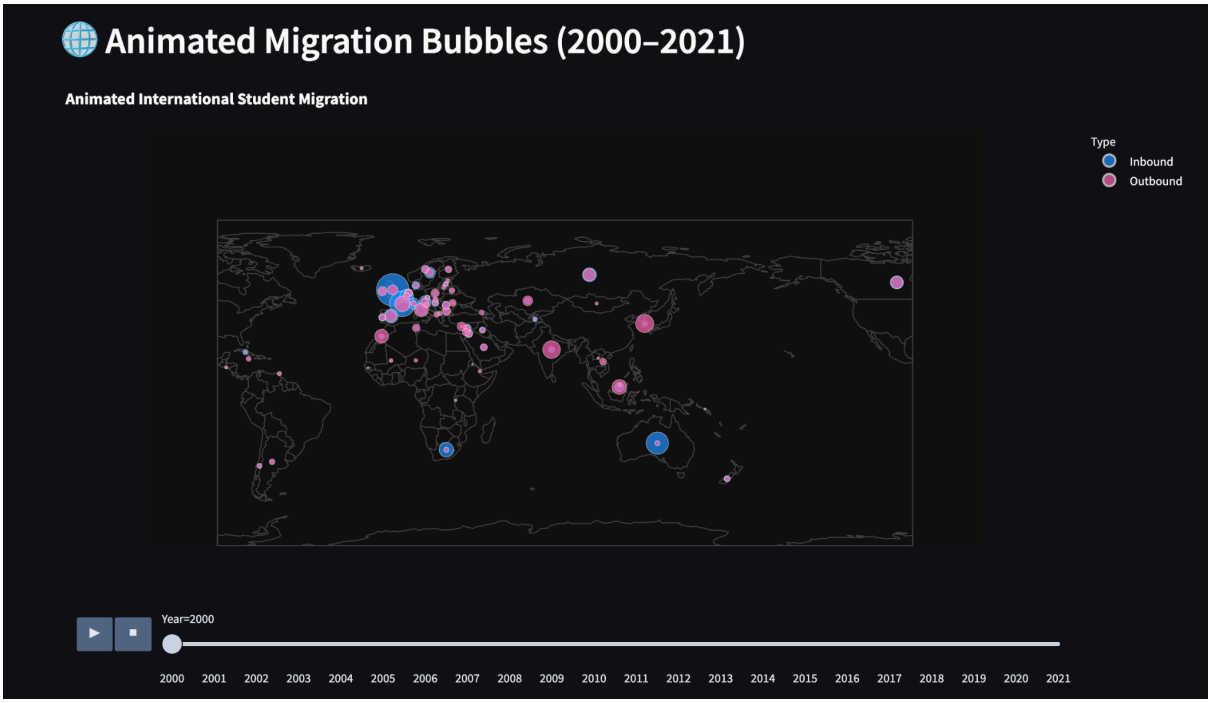
As the decade progressed, the 2010 snapshot revealed the early signs of a more interconnected world. A larger number of countries began to engage actively in sending and receiving students. Notably, China, India, and Southeast Asian nations exhibited growing outbound migration. Inbound hubs such as Australia and the UK expanded further, while Europe as a whole solidified its position as a central magnet for international students.

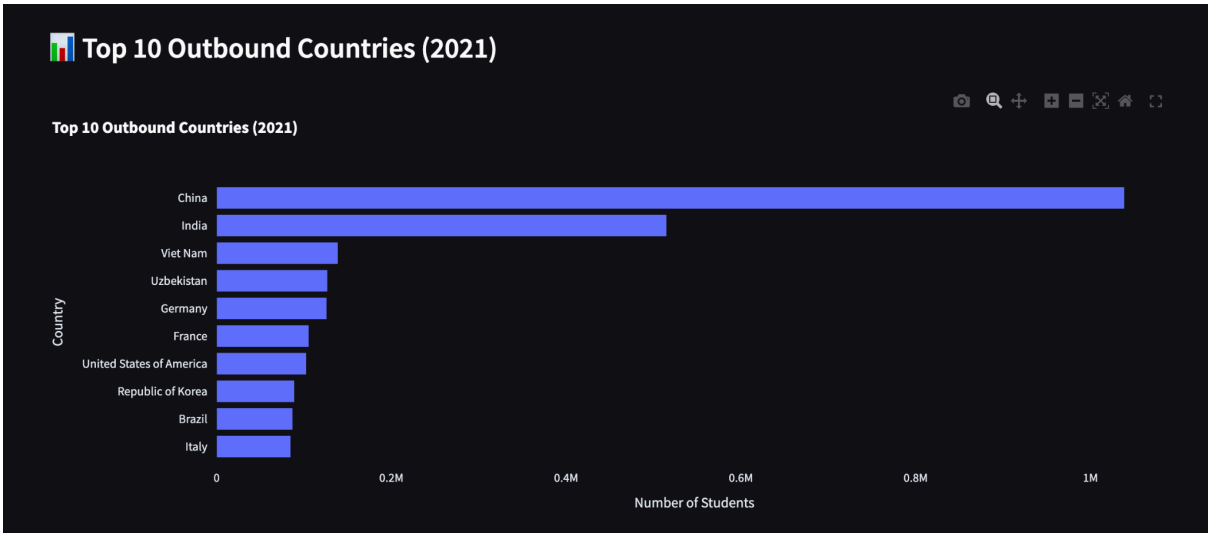
By 2021, international student mobility had not only intensified but diversified. Inbound flows into major economies became significantly larger, represented by the dramatic growth in bubble sizes. The United States, Australia, the United Kingdom, and Germany emerged as dominant global destinations. At the same time, China rose sharply as the world's largest sender of outbound students, followed by India and other Asian economies. Outbound migration patterns became more dispersed, no longer concentrated in a handful of nations but rather involving a wider range of countries from different regions.

Throughout these two decades, several overarching trends can be observed:

1. **Expansion and Diversification:** Both the number of mobile students and the number of participating countries increased dramatically, reflecting a broader democratization of international education.
2. **Economic Correlation:** Wealthier nations consistently attract higher numbers of inbound students, suggesting that economic strength remains a key driver of educational migration.
3. **Rise of Asia:** Asia shifted from being predominantly a source of outbound students to becoming a crucial player in shaping global mobility patterns, both as senders and increasingly as receivers.
4. **Resilience Despite Challenges:** Even in the face of global disruptions such as the COVID-19 pandemic, the data shows sustained student flows in 2021, underscoring the resilience and continued demand for international education.

These findings highlight how global education has evolved into a complex, multi-directional network of opportunities, aligning closely with Sustainable Development Goal 4 (SDG 4), which advocates for inclusive and equitable quality education and the promotion of lifelong learning opportunities for all.





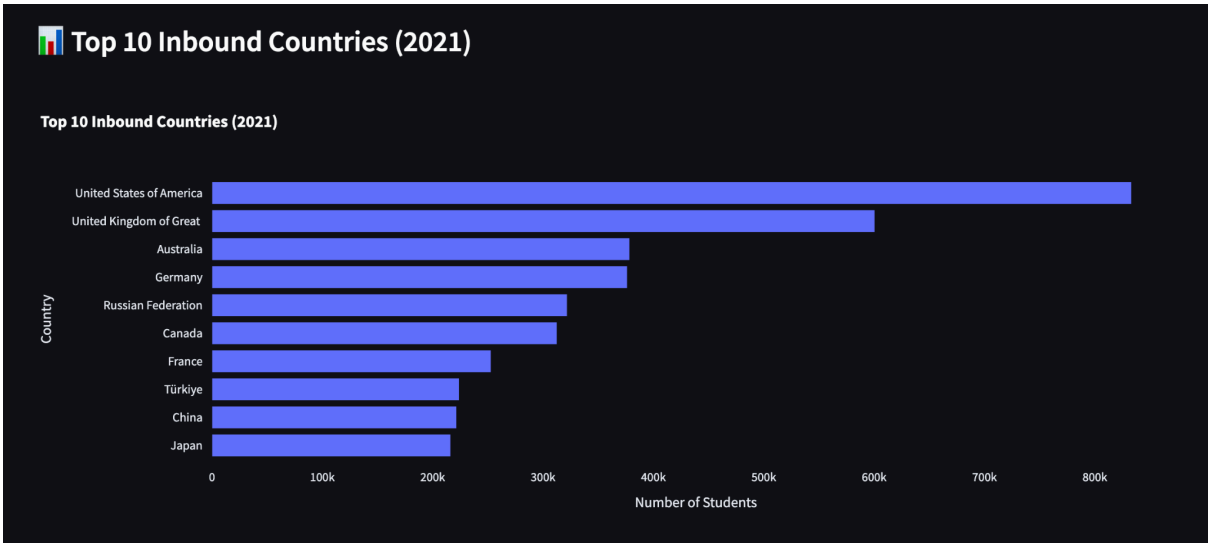


Figure 2-4. The Animated Map (2000–2021) and Top 10 Inbound/Outbound Countries (2021).

B. 2022 Flow Lines Map:

The 2022 international student flow map reveals several key insights:

1. **Dominant Destinations:** The United States and the United Kingdom remain the largest recipients of international students. Thick lines represent major inflows from Asia, Europe, and Latin America.
2. **Emerging Intra-Asia Mobility:** A significant volume of students is moving between Asian countries, particularly from India, Vietnam, and Bangladesh to destinations such as Japan, South Korea, and Malaysia. This trend highlights the strengthening role of regional education hubs in Asia.
3. **European Educational Connectivity:** Europe shows dense internal student mobility, with strong educational exchanges between EU countries. Initiatives like Erasmus likely contribute to this vibrant intra-European student movement.

4. **Latin American Patterns:** Latin American students, especially from Brazil, Colombia, and Argentina, predominantly head toward the United States and Spain for higher education opportunities.
5. **Access Gaps:** Sparse outbound flows from Sub-Saharan Africa point to ongoing challenges in equitable access to international education pathways.

Overall, the 2022 snapshot visualizes a complex, multi-centered network of global student mobility, demonstrating both traditional and emerging educational migration routes.

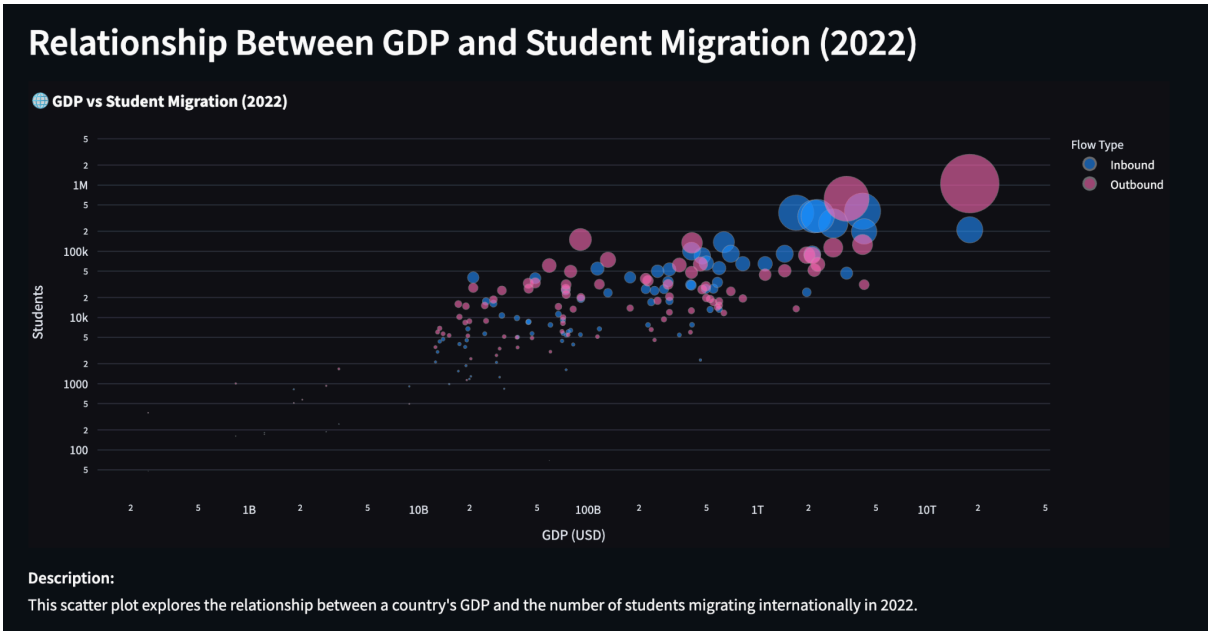
Figure 5-6. 2022 Major Student Flows and Top 10 Routes by Volume.

C. GDP vs Students Scatter Plot:

The scatter plot reveals several important trends between a country's economic strength and its international student flows:

1. **Positive Correlation:** Generally, countries with higher GDP levels tend to have higher numbers of both inbound and outbound international students. This suggests that economic resources enable better access to education abroad and greater attractiveness as education destinations.
2. **Top Economies Dominate:** Economies like the United States, China, Germany, and the United Kingdom are positioned in the upper right, indicating they are both major sources and hosts of international students.
3. **Outbound Mobility from Developing Economies:** Several developing countries with moderate GDPs (e.g., India, Vietnam, Nigeria) show relatively high outbound student numbers, reflecting strong demand for education abroad despite economic constraints.
4. **Inbound Disparities:** Some wealthy countries have relatively fewer inbound students compared to their GDP size, suggesting that factors beyond economics, such as language, visa policies, or educational reputation, also impact inbound attractiveness.
5. **Outliers and Exceptions:** A few smaller economies (e.g., Malaysia, the UAE) punch above their economic weight by attracting large numbers of international students, indicating the emergence of new regional education hubs.

Overall, the scatter plot highlights the economic dimension of global education mobility and points to persistent inequalities in access and destination attractiveness.



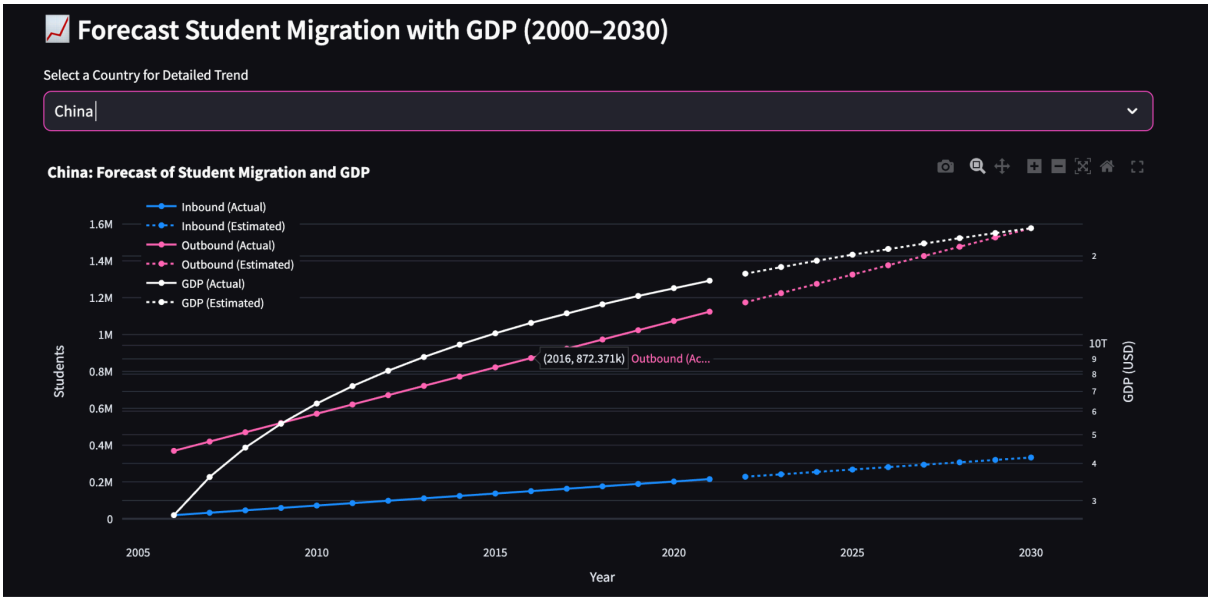


Figure 7-8. GDP vs Students Scatter Plot and the Forecast Student Migration with GDP(2000-2030).

8. Intellectual Merit & Practical Impact

Academically, this project contributes to the growing body of research at the intersection of data visualization, international education, and migration studies. By integrating multi-source data into a cohesive and interactive platform, we demonstrate how visual tools can support comparative, temporal, and geographic analysis of complex global mobility trends. Our work builds upon existing thematic mapping strategies while applying them to underexplored educational datasets.

Practically, our dashboard provides actionable insights for a range of stakeholders. Governments and universities can use the visualized data to better plan scholarship distribution, adjust international recruitment strategies, and promote more equitable access to education. Non-governmental organizations focused on development may also leverage these findings to understand how outbound student flows can contribute to long-term capacity-building in developing countries through knowledge transfer and return migration. In addition, the platform supports prospective students by offering transparent, data-driven comparisons of global study destinations, helping them make more informed decisions about where to study based on economic context, mobility trends, and educational opportunity. Looking ahead, the system's framework can be extended to incorporate forecasting models that predict future flows based on GDP growth or political change, making it a valuable tool for both short-term planning and long-term strategy.

9. Reflection on Growth and Learning

This project marks a leap from static infographics to an interactive, multi-layered visualization product.

Throughout this project, we experienced a significant learning curve that strengthened both our technical and collaborative capacities. We learned how to manage a complex pipeline—from sourcing and cleaning international datasets to deploying a live visualization

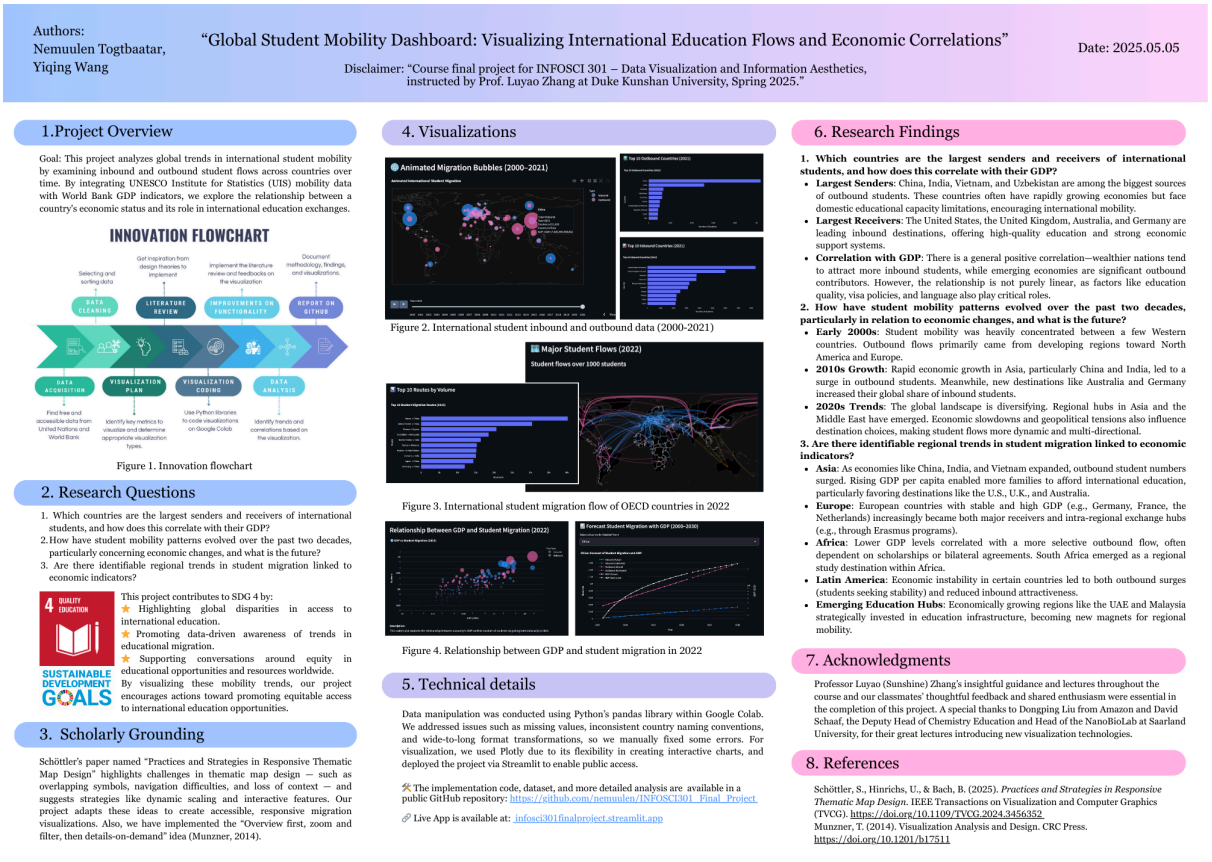
dashboard—while maintaining consistency and clarity in our narrative. Working as a team, we each took on different but interconnected roles in design, analysis, and development, gaining a deeper appreciation for the interdisciplinary nature of data visualization. Our work also challenged us to reflect on broader issues of equity, inclusion, and accessibility in how we communicate data. Importantly, this project helped us connect our academic interests to real-world challenges, particularly those aligned with the UN Sustainable Development Goals. Through each step, we developed a more critical and creative perspective on how data can inform, inspire, and empower decision-making in global education.

Based on our classmates' feedback, we improved the first visualization by making it animated. To better support government decision-making, we also created individual graphs for each country, showing the relationship between GDP and student numbers, along with projections through 2030.

The Zhouzhuang field trip reminded us that meaningful communication—whether about the body or the world—requires care in tone, empathy in design, and attention to accessibility.

10. Supplementary Materials

- GitHub Repository: https://github.com/nemuulen/INFOSCI301_Final_Project
- Demo Video: https://duke.box.com/s/1upqgdtsr2qphtmh19cwumnjz4yzb684
- Live App: infosci301finalproject.streamlit.app
- Project Poster:



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Competing Interests

We declare no competing interests.

References

Schöttler, S., Hinrichs, U., & Bach, B. (2025). *Practices and Strategies in Responsive Thematic Map Design.* IEEE Transactions on Visualization and Computer Graphics (TVCG). https://doi.org/10.1109/TVCG.2024.3456352

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