HappiScope

Exploring the Multidimensional Nature of Global Happiness

HappiScope

HappiScope Team

Chang Jin (403930) **Rizhong Lin** (366842) **Anlan Wang** (403909)

Visit the Live Demo

GitHub Repository

`com-480-data-visualization/HappiScope`

1 Introduction: The Path to HappiScope

In an increasingly data-driven world, metrics that quantify human well-being have become essential tools for understanding societal progress. Traditional economic indicators like GDP often fall short in capturing what truly matters to people's lives. This is where the concept of measuring happiness enters–attempting to holistically represent the quality of life across different societies.

HappiScope was born from our desire to create an intuitive, interactive platform that makes this wealth of happiness data accessible and interpretable. Our goal was to transform the rich but complex World Happiness Report datasets into visual insights that reveal patterns and relationships in global well-being that might otherwise remain hidden in tables and statistics.

Project Vision

We set out to develop an interactive web-based platform for visualizing World Happiness Report data from 2015 to 2024. The platform provides an intuitive interface for users–including policymakers, researchers, educators, and the general public–to explore global happiness trends, understand the contributing factors, and analyze correlations with other key indicators like population and the Human Development Index (HDI).

Our Data Sources

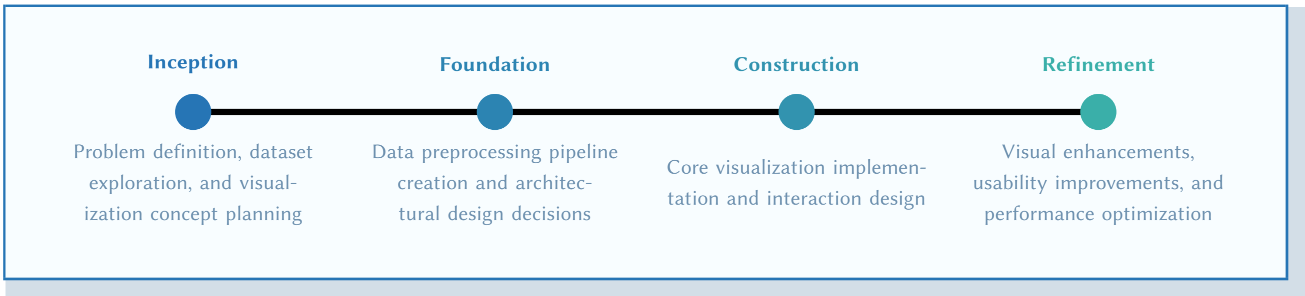
- **World Happiness Reports (2015–2024)**, covering over 150 countries
- **United Nations Human Development Index (HDI)** data
- **World Bank Population Statistics**

The journey from data to insight required careful processing, thoughtful design choices, and creative implementation. In this process book, we document our path from concept to final product, sharing the challenges we encountered and the solutions we devised along the way.

2 Our Development Journey

2.1 Evolution from Initial Concept to Final Implementation

Our development process evolved through four distinct phases, each building upon the previous one while refining our approach based on discoveries and challenges.



2.1.1 Data Processing Phase

We began by collecting multiple datasets from disparate sources: a decade of World Happiness Reports, HDI data from the United Nations, and population figures from the World Bank. The initial challenge was significant–these datasets used different country naming conventions, varied time periods, and inconsistent formatting.

Pipeline Development: We developed a sophisticated Python-based pipeline to harmonize these datasets. Key processing steps included standardizing country names by mapping them to ISO Alpha-3 codes, which served as our universal identifier across all data sources.

Data Interpolation: For countries with missing years in the time series, we applied appropriate interpolation techniques to estimate values while preserving temporal integrity. The most complex task was reconciling differences in geographical definitions, particularly for territories that had changed status during the decade.

Optimization for Web: The processed data was transformed into optimized JSON structures tailored for web visualization, with careful attention to file size to ensure fast loading times even on slower network connections.

2.1.2 Design Phase

With our data prepared, we turned to designing the user experience. We created wireframes for the four main visualization components: the global map view, country comparison interface, factor analysis section, and the dashboard that would tie everything together.

Component Design: We created detailed wireframes for each visualization component, carefully considering how they would work both independently and together.

Navigation Flow: Early sketches revealed navigation challenges–how would users intuitively move between different views while maintaining context? We addressed this by designing a persistent top navigation bar that remains visible across all views. We also designed a linked view system: e.g., if a user selects a country on the map and then navigates to the comparison view, that country remains selected and will be pre-loaded.

Interactive Model: We designed dynamic cross-view interactions so that user selections, such as choosing a country or a year, would automatically update all relevant visualizations in real time. For instance, selecting a country on the map instantly loads its historical happiness trends in the line chart.

Color was another critical design consideration. We needed a scheme that would meet multiple requirements:

- ✔ **Represent happiness values** on a choropleth map
- ✔ **Maintain consistency** across visualizations
- ✔ **Be accessible** to users with color vision deficiencies
- ✔ **Ensure contrast** with interface elements

After testing several options, we settled on a sequential color scheme from blue to amber that effectively communicated happiness gradients while offering excellent perceptual properties.

2.1.3 Website Implementation

With designs finalized, we moved to implementation using React as our foundation. We divided the work into modular components that could be developed in parallel before integration.

Technology Stack: For visualizations, we leveraged a combination of libraries–React Simple Maps for geospatial representation, Nivo for standard charts, and custom D3.js implementations for specialized visualizations that required fine-grained control.

State Management: One of our most significant technical challenges was optimizing interactions between components, e.g., updating the line chart, radar chart, and comparison table when a user selects a country on the map. We addressed this by organizing our React components around shared contextual state using the Context API and custom hooks, enabling consistent interactions without tightly coupling the views.

System Architecture: We implemented a centralized state management system that efficiently propagated changes while minimizing redundant calculations and renders, ensuring smooth user experience. Each visualization module was developed as an independent component, enabling parallel development.

2.1.4 Refinement Phase

The final development phase focused on enhancing the visual design and improving usability across different devices and contexts.

Responsive Design: We implemented responsive layout adjustments for different screen sizes, ensuring the application would provide a good experience on devices ranging from desktops to mobile phones.

Visual Enhancements: We added animated transitions between different web pages to provide visual continuity and created detailed tooltips to expose additional data on demand, improving the overall user experience.

Performance Optimization: We implemented data memoization strategies to prevent unnecessary recalculations, lazy-loaded components to improve initial loading time, and carefully managed component re-rendering to maintain smooth interactions even when manipulating large datasets.

2.2 Challenges and Solutions

Throughout development, we encountered several significant challenges that shaped our approach and solution:

Challenge 1: Handling Missing and Inconsistent Data

Problem: The World Happiness Report has evolved over the years, with varying country coverage and occasionally changing methodologies.

Solution: We built a robust data preprocessing pipeline to address missing values across different years and datasets. For time series gaps occurring between known values, we used linear interpolation to estimate the missing entries. When missing values occurred at the start or end of a country's timeline (i.e., the first or last year in the range), we applied forward-fill or backward-fill strategies, assigning the closest available value to the missing year. This approach preserved temporal trends while avoiding distortion from artificial estimates.

Challenge 2: Balancing Visual Complexity with Usability

Problem: The multidimensional nature of happiness data (six factors across 150+ countries over 10 years) created potential for overwhelming complexity.

Solution: We implemented progressive disclosure principles—showing essential information first with the ability to drill down for details. Interactive filters allow users to focus on specific regions, time periods, or factors, reducing visual complexity while maintaining analytical depth.

Challenge 3: Creating Meaningful Geographical Representations

Problem: Standard map projections distort country sizes, potentially leading to visual emphasis bias toward larger countries regardless of population.

Solution: We selected the Equal Earth projection, which preserves the relative sizes of countries while maintaining recognizable shapes. We also implemented population-adjusted visualization options to provide alternative perspectives beyond raw geographical representation.

Challenge 4: Optimizing Performance for Interactive Visualizations

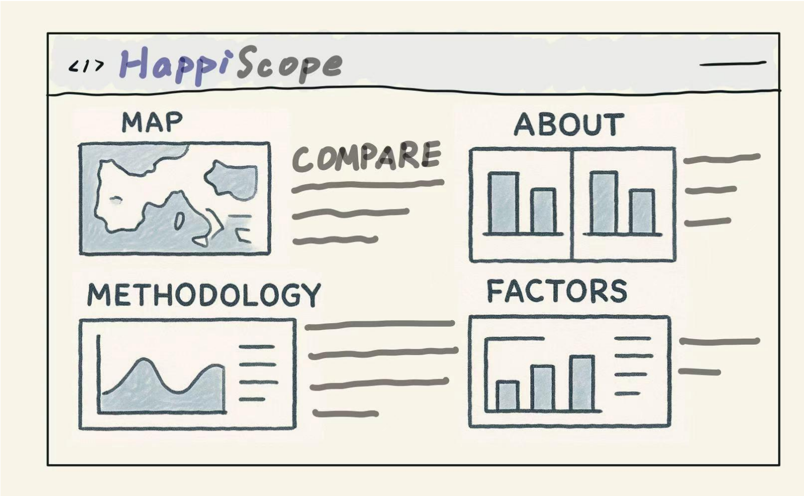
Problem: Interactive filtering and animated transitions across large datasets created performance bottlenecks.

Solution: We implemented data aggregation strategies, efficient state management using React hooks, and throttled updates for smooth interactions. Complex calculations were memoized to prevent redundant processing.

3 From Sketch to Implementation: Visual Evolution

Our visualization components evolved significantly from initial sketches to final implementation. This section documents that transformation process and the design decisions that shaped it.

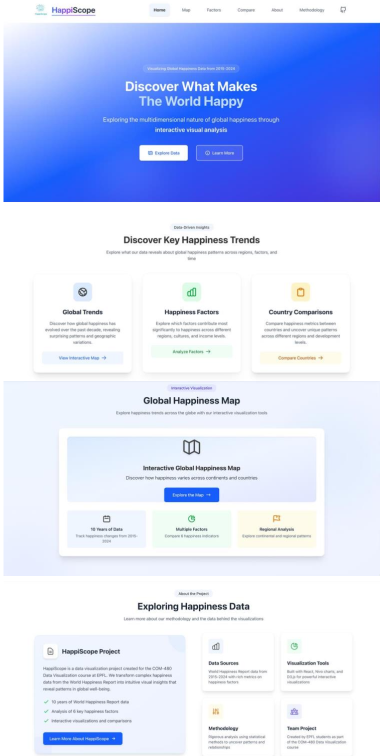
3.1 Home Page Evolution



(a) Sketch Design

Element	Sketch Design	Website Implementation
Landing Page	No landing page	Add a bold, blue-toned main landing page
Module layout	Four sections	Separate the display of Trends, Map, and other data exploration views.

(c) Evolution



(b) Website Implementation

Figure 1: Home page evolution from concept to implementation. (a): Initial sketch design showing the main navigation layout and module organization. (b): Final website implementation featuring a bold blue-toned landing page with interactive module previews, descriptive content, and a consistent visual language. (c): Evolution table comparing elements between the sketch design and website implementation.

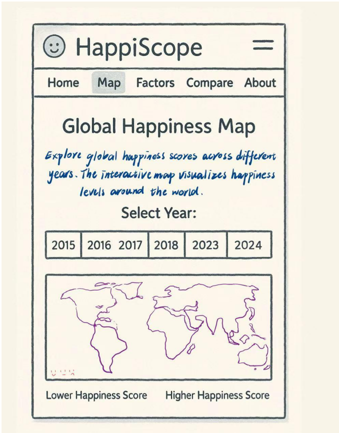
The home page underwent substantial refinement from our initial concept. Our early sketch (Figure 1a) envisioned a grid-based layout with simple thumbnail previews. As we developed the platform, we recognized the need for a more engaging introduction to the project that would immediately communicate its value.

The final implementation (Figure 1b) features a visually striking hero section with animated elements that capture attention. We added concise explanatory text for each visualization module, helping users understand what insights they could expect before navigating to detailed views. The clean, modern aesthetic uses gradients and subtle animations to create visual interest while maintaining clarity and focus on the content.

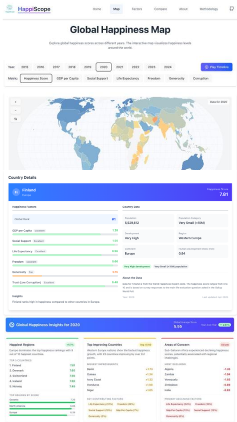
3.2 Map Visualization Evolution

The map visualization saw significant enhancement from sketch to implementation. Initially (Figure 2a), we planned a simple choropleth map with basic year selection. Through iterative development, we recognized opportunities to add valuable context and control options.

In the final version (Figure 2b), we added a sophisticated legend that updates dynamically based on data distribution, a smooth timeline slider with play/pause functionality for temporal exploration, detailed country tooltips providing all factor values, and regional filtering options. We also refined the color scale to ensure clear visual distinction between happiness levels while maintaining accessibility for users with color vision deficiencies.



(a) Sketch Design



(b) Website Implementation

Element	Sketch Design	Website Implementation
Metric	/	Add metric/ factor selection
Auto play	/	Add a function to play the timeline automaticly
Countriy Detail	/	Can select a country in the map and present the detail
Global insights	/	Add global insights for the selected year

(c) Evolution

Figure 2: Map visualization evolution showing key design improvements. (a): Initial sketch with basic year selection and simplified world map outline. (b): Enhanced implementation featuring metric selection, auto-play timeline functionality, detailed country information display, and global insights for the selected year. (c): Evolution table comparing elements between the sketch design and website implementation.

3.3 Factor Analysis Evolution

The factor analysis visualization underwent perhaps the most dramatic transformation. Our original sketch (Figure 3a) proposed a basic correlation view with limited interactivity. Through development, we expanded this into a comprehensive analytical tool.

The final implementation (Figure 3b) features interactive scatter plots with customizable axes, allowing users to explore relationships between any pair of variables. We added regression lines to visualize trends, implemented a correlation heatmap for quick identification of strongly related factors, and created detailed tooltips that reveal country-specific data points. The ability to filter by region or development level enables more targeted analysis.

3.4 Country Comparison Evolution

The country comparison visualization evolved from a basic table-based selection interface (Figure 4a) to a flexible multi-country analysis tool with intuitive search functionality. We recognized that limiting comparisons to just a few predefined countries would constrain analytical possibilities.

In the final implementation (Figure 4b), users can select multiple countries through an intuitive interface with search functionality and regional grouping options. The visualization displays time series trends of overall happiness and individual factors, with synchronized highlighting across views. We added radar charts to provide an immediate visual comparison of factor compositions between countries, making structural differences in happiness determinants instantly apparent.

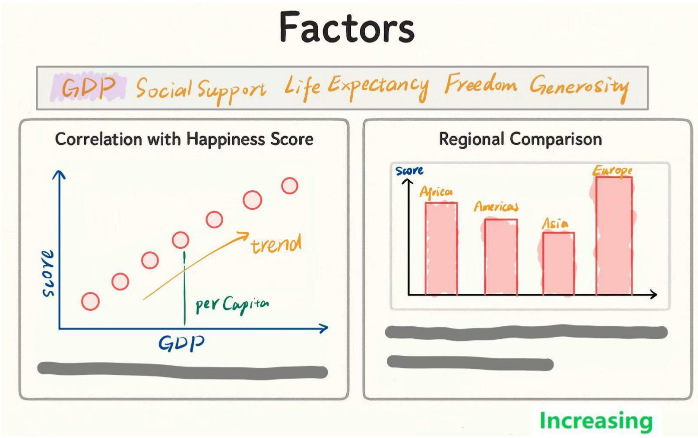
4 Methodology and Technical Implementation

Our project required a structured methodology spanning from data processing to frontend implementation. This section details our technical approach and the tools we employed.

4.1 Data Processing Pipeline

We implemented a comprehensive data processing pipeline to ensure high-quality input for our visualizations:

Data Collection and Cleaning. The World Happiness Report data required significant preprocessing. We wrote Python scripts to harmonize datasets across years, standardizing column names and ensuring consistent country iden-



(a) Sketch Design

Element	Sketch Design	Website Implementation
Term Explanation	No explanation	Add terminology explanations
Module layout	Two sections	Add Trend Over Time, Impact by Development, Key Findings about the factor

(c) Evolution

(b) Website Implementation

Figure 3: Factor analysis visualization evolution. (a): Initial sketch showing correlation plots and regional comparison of factors. (b): Enhanced implementation featuring terminology explanations, four detailed analysis modules including trend over time, impact by development level, and key findings about each happiness factor. (c): Evolution table comparing elements between the sketch design and website implementation.

tification. Missing values were handled through appropriate interpolation techniques depending on the nature of the gap–linear interpolation for short gaps in time series data and more sophisticated methods for structural missingness.

Country Name Standardization. A critical challenge was normalizing country names across datasets. We created a mapping system that reconciled different naming conventions (e.g., "United States" vs. "United States of America" vs. "USA") to standard ISO 3166-1 alpha-3 codes, which served as unique identifiers throughout our application.

Geospatial Integration. To enable map-based visualizations, we integrated GeoJSON data with our happiness metrics. This required careful alignment between country identifiers in our statistical data and the corresponding geographical boundaries.

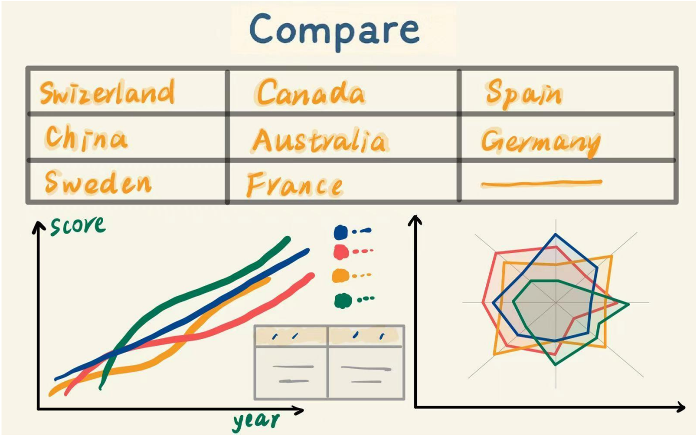
Data Interpolation. For missing data in intermediate years, linear interpolation is employed to estimate the absent values based on adjacent known data points. In instances where missing values occur at the boundaries of the time series, the imputation is performed by carrying forward or backward the nearest available observation, respectively, to preserve temporal continuity.

Data Transformation. The final step in our pipeline transformed the processed data into optimized JSON structures designed specifically for web visualization. We created separate files for different aspects of the data to enable efficient loading and minimize bandwidth requirements.

4.2 Analysis Techniques

To extract meaningful insights from the happiness data, we applied several analytical approaches:

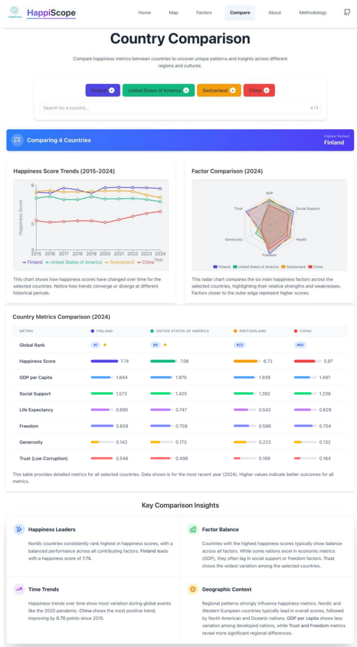
Correlation Analysis. We computed Pearson correlation coefficients between the overall happiness score and each contributing factor, identifying which elements showed the strongest relationships with overall well-being across different regions and development levels.



(a) Sketch Design

Element	Sketch Design	Website Implementation
Search Bar	No search bar	Add a search bar for users to add countries freely
Module layout	Two sections	Add metric comparison and key comparison insights

(c) Evolution



(b) Website Implementation

Figure 4: Country comparison tool evolution. (a): Initial sketch showing a table-based country selection interface with time-series trend lines and radar chart for factor comparison. (b): Final implementation featuring an intuitive search interface for country selection, interactive time series visualization, and enhanced radar charts for detailed factor comparison across selected countries. (c): Evolution table comparing elements between the sketch design and website implementation.

Temporal Trend Analysis. By analyzing year-over-year changes in happiness scores and factors, we identified trends and potential inflection points. This allowed us to pinpoint specific years and regions where significant changes occurred, such as notable declines in regions experiencing economic or political instability.

Regional Comparison. We aggregated countries into continental and sub-regional groups to enable comparative analysis at different geographical scales. This revealed distinctive patterns in how happiness and its components vary across different parts of the world.

Development-Based Analysis. Countries were grouped according to their Human Development Index (HDI) levels to explore how the determinants of happiness might differ between highly developed and developing nations.

4.3 Implementation Technologies

Our technology stack was selected to provide the optimal balance between development efficiency, visualization capabilities, and performance:

Frontend Framework. We built the application using React, which provided a component-based architecture ideal for complex interactive visualizations. React's virtual DOM and efficient rendering system enabled smooth user experiences even with data-intensive visualizations.

Visualization Libraries. Different visualization needs required different specialized tools:

- **React Simple Maps** for geographic visualizations, offering excellent React integration and efficient rendering of map data
- **D3.js** for custom visualizations requiring fine-grained control, particularly interactive scatter plots and correlation heatmaps

Nivo for standard chart types like bar charts, line charts, and radar charts, providing responsive and aesthetically pleasing visualizations with minimal configuration

Framer Motion for animations and transitions, enhancing the user experience through fluid visual feedback

Styling and UI. Tailwind CSS was used for consistent styling across the application, with custom design tokens ensuring visual coherence. The responsive layout adapts to different screen sizes, from desktop monitors to tablets.

5 Team Contributions

The development of HappiScope was a collaborative effort, with each team member bringing unique strengths to the table. We shared responsibilities to ensure collective ownership of the final product while drawing on our expertise.

Chang Jin (403930)	Rizhong Lin (366842)	Anlan Wang (403909)
✔ **Led** data preprocessing	✔ **Developed** web presence	✔ **Created** initial designs
✔ **Conducted** data analysis	✔ **Created** interactive visualizations	✔ **Designed** sketches & prototypes
✔ **Ensured** data accuracy	✔ **Built** user interface	✔ **Shaped** user experience
✔ **Compiled** process book	✔ **Refined** process book	✔ **Produced** final screencast

6 Conclusion and Future Work

The HappiScope project is our attempt to make complex happiness data accessible and insightful through interactive visualization. Along the way, we gained valuable experience in data transformation, visual design, and interactive development.

6.1 Lessons Learned

Data quality is critical – Even the most refined visualizations can't fix poor data. Investing in preprocessing early saves time later.

Build complexity gradually – Starting simple and adding features step by step let us stay agile and continuously functional.

Users see what we don't – Informal testing revealed unexpected behaviors, helping us refine interaction design meaningfully.

6.2 Future Directions

Smarter predictions – Integrating advanced models could offer richer forecasts of future happiness trends.

Richer context – Adding data on politics, economics, or health could explain shifts in happiness over time.

Personalized pathways – Designing guided analysis flows for different users (e.g., policymakers, educators) could expand the tool's impact.

HappiScope shows how visual storytelling can turn abstract data into tangible insight. We hope it contributes to a richer understanding of happiness—one that goes beyond economics and embraces the full spectrum of human well-being.