

Pathfinder: University Exploration Application

Design Rationale

Data Visualization and Decision Making

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Introduction

I designed the Pathfinder application to guide prospective students through a simplified, structured exploration of higher-education options. My aim was to integrate data visualization principles, cognitive bias mitigation strategies and human cognitive design principles in order to balance relevant and comprehensive information delivery with intuitive, low-effort decision support. My inspiration for developing Pathfinder stemmed from my own experience navigating the often overwhelming and opaque process of university selection. Having personally confronted the challenges, uncertainties, and cognitive pitfalls that exist in the process of finding a university, I thought of the topic as both something I had an acceptable understanding of (in terms of the types of information students truly need, the decision-making problems they are forced to face, and the biases most commonly influencing their choices) and as a project that I was willing to approach with technical rigor, empathy and insight into the student experience.

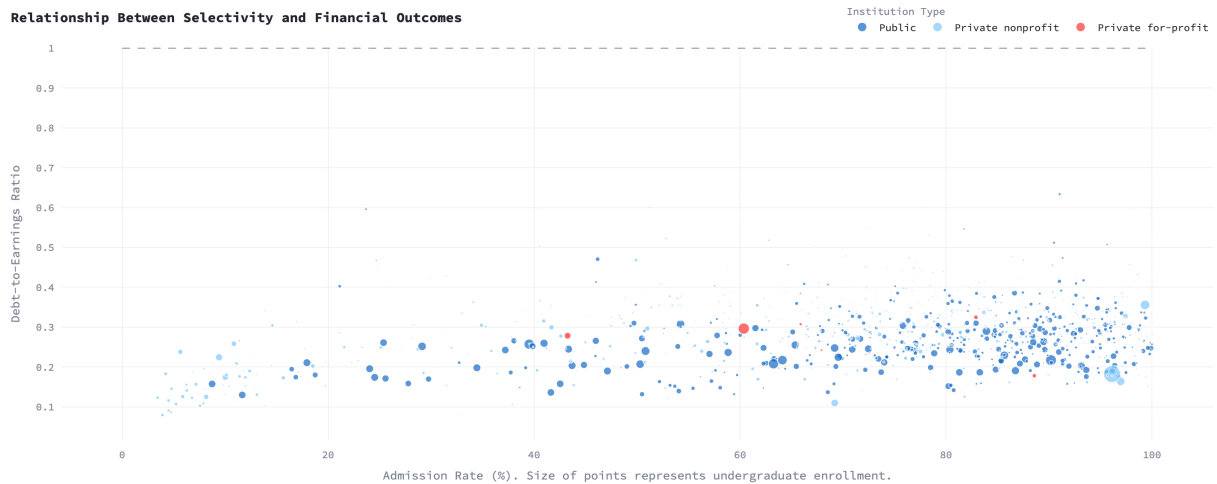
Although this submission focuses primarily on institution-level data (current and historical), earlier iterations of the application did explore a more granular integration of data by field of study. I tried to implement program-level metrics, as student outcomes can vary more within universities and across disciplines than between institutions overall. I also experimented with incorporating evaluative data from established international ranking bodies such as CWUR, Shanghai, and Times Higher Education, with the goal of allowing students to understand institutional performance across multiple dimensions and criteria. However, due to time constraints and concerns regarding the cohesions and integration of these

more complex data sources, I ultimately chose to prioritize a streamlined, fully functional and coherent application focused at the institutional level. Looking ahead, I hope to expand Pathfinder's scope to include program-level insights, postgraduate offerings, and global higher education institutions.

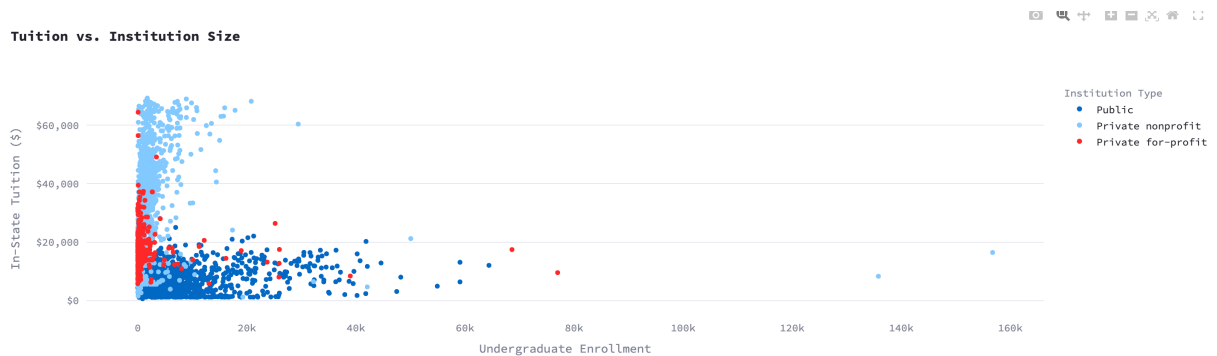
Overall Design Philosophy

Pathfinder was designed with several core principles in mind:

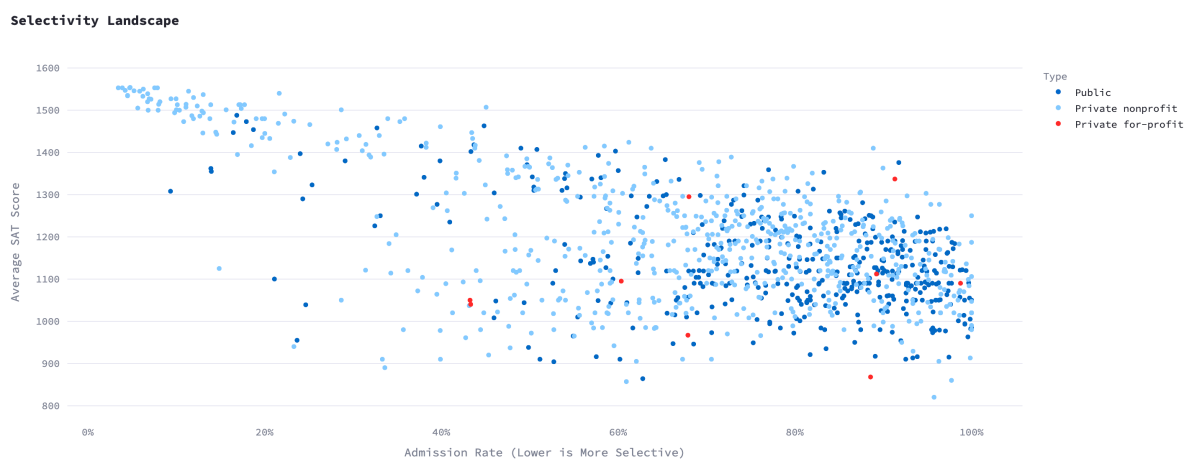
- **Progressive Information Disclosure:** My aim was to organize data by topic and depth, in a way that allows for a layered approach where users can progressively explore deeper levels of information. This, I hope, reduces cognitive load while still providing access to comprehensive data. Broadly, the *Explore Universities* tab serves a more 'macro' perspective, allowing the user to gain information on the overall university landscape given a filtered pool of universities, rather than of a single institution. This landscape is divided into *Selectivity*, *Cost*, *Outcomes*, *Institution*, and *Diversity*, in an attempt to reduce clutter by using informational chunking to optimize visual processing, and enhance explorability. My goal with *Explore Universities* is for students and parents to gain a better understanding of the overall existing options, of the relationship between factors they might be considering, and how institutions compare within these dimensions. Through this structure, users can move from general insights to specific evaluations in a manageable and purpose-driven way.



Progressive Information Disclosure: Landscape Macro-description: Outcomes



Progressive Information Disclosure: Landscape Macro-description: Cost



Progressive Information Disclosure: Landscape Macro-description: Selectivity

- **Neutral Color Palette:** I deliberately moved away from value-laden color schemes (red/yellow/green) that might introduce judgement bias. For instance, a very high admission rate might be perceived as undesirable if coded in red, even though its desirability and appropriateness depends entirely on the student's goals, context and academic profile. Instead, I mostly employed monochromatic blue palettes for most visualizations and metrics, reserving color variations primarily only for categorical distinction rather than implied value judgement. This design choice helps mitigate acceptance bias where users might prematurely filter options based on color-coded signals rather than considering personal needs, and aims to avoid subconscious cues embedded in color. It also reduced cognitive friction. A neutral color palette goes hand-in-hand with a consistent visual language in visual elements (cards, charts, typography) to reduce the learning curve and cognitive friction. I hope to have created a visual grammar that users can quickly internalize, allowing them to focus on content rather than deciphering interface elements.

Median SAT Score

947

National Average Range



Median ACT Score

18

National Average Range



Median SAT Score

1553

Top 1%



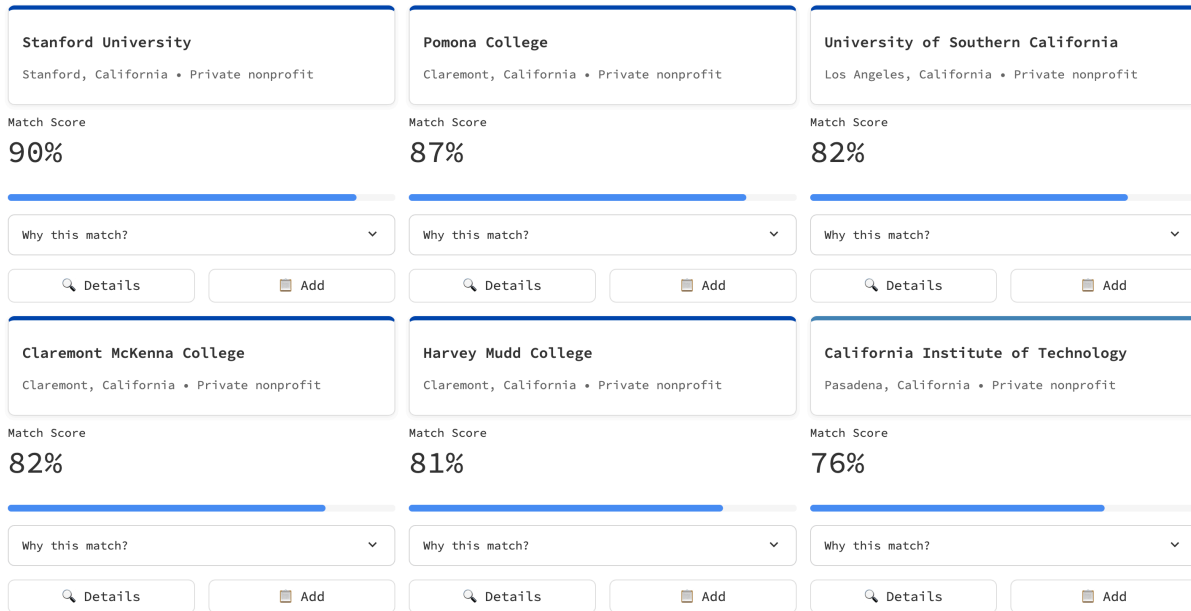
Median ACT Score

35

Top 1%



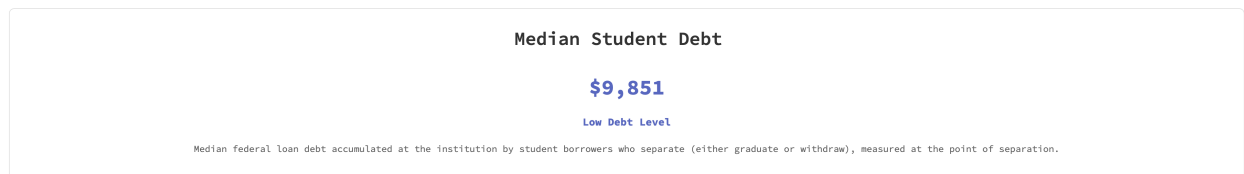
Click on a university card to see more details or take actions.



Neutral Color Palette Examples

- **Contextual Comparisons:** Throughout the application, I attempted to put care towards contextualizing data points. The use of national averages, peer comparisons, and reference points for single number metrics were used to address anchoring biases, preventing a single trend or data point from dominating perception. These contextual comparisons are mostly present and leveraged in the detailed view of a specific institution (After clicking *View Details* for a given institution). Contextual comparisons and neutral color palettes are two strategies I employed to mitigate framing effects, a cognitive bias I know to be wide-spread when exploring universities.

Student Debt



Context: 6.6% of first-time, full-time undergraduate students at this institution take out federal loans.

Contextual Comparison Example from Stanford University

- **Confirmation and Preference Bias Mitigation:** Pathfinder intentionally avoids using name-based search as the primary mechanism for discovering and shortlisting universities. While the functionality is supported and preserved via Streamlit's `data_editor` API, it is not at all emphasized within the user interface. Instead, my intention was to center the discovery experience around objective numerical and categorical criteria as that serve as exploratory filters and as attributes to calculate the fit between a student and an institution. This shift was done deliberately to minimize the influence of confirmation bias—where users might seek out and validate existing preferences—and preference bias, which can cause individuals to favor familiar institutions over better-suited alternatives. By prompting users to engage with a broader range of institutions through transparent, personalized filters, Pathfinder encourages open-minded, evidence-based exploration. I hope this approach supports more equitable outcomes and allows students to uncover universities they would not have previously considered.
- **Transparency About Missing Data:** Transparency about missing data was a central concern in the design of the Pathfinder application. Without clear disclosure, users might unknowingly base decisions on a non-representative subset of institutions, leading to selection bias and distorted insights. To mitigate this, we explicitly state the percentage of institutions excluded due to missing data and use hover-for-info indicators to provide context without cluttering the interface. The need for clear, and transparent warnings or mechanisms to treat missing data became quickly apparent when developing the application. For a variety of reasons, many institutions, even the most prominent and well-known ones, often omitted publicly releasing statistics about their student body, especially those of public type. Rather than omitting institutions with incomplete information, we acknowledge their presence while clearly marking their data limitations—an approach aligned with best practices in uncertainty visualization. This strategy communicates the limits of the data and supports ethical, informed decision-making. Furthermore, it strikes a careful balance between completeness and usability: including institutions with partial data expands the scope of user options while providing transparency safeguards to prevent misinterpretation or overconfidence in the visualized patterns. Unfortunately, I was not able to come up with a more robust and efficient mechanism to deal with non-reporting institutions.

This tool only measures and returns matches based purely on academic and preferential criteria. It does not consider extracurricular activities, campus culture, or other non-academic factors. We are working on adding more features to the tool :)

Admission Rate vs. Average SAT Score [?]

Note: 83% of institutions in your filter are not shown due to missing admission rate or SAT score data.

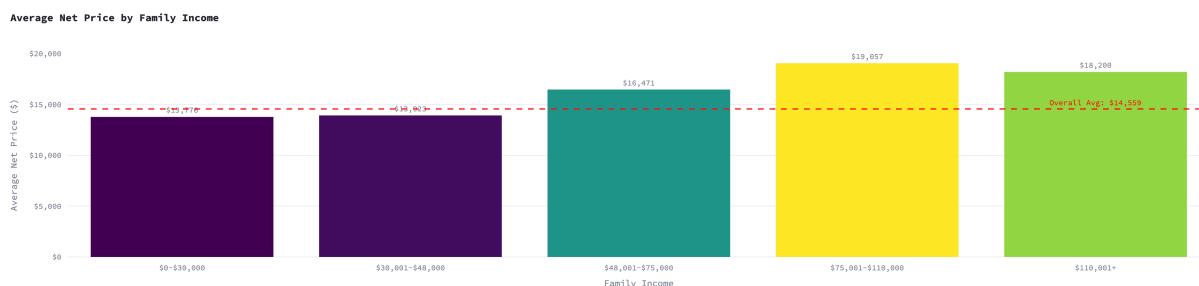
Median Debt vs. Median Earnings (10yr) [?]

Note: 25% of institutions in your filter are not shown due to missing debt or earnings data.

Transparency About Missing Data Examples

Principles and Cognitive Considerations: Representative Examples

1. Average Net Price by Family Income

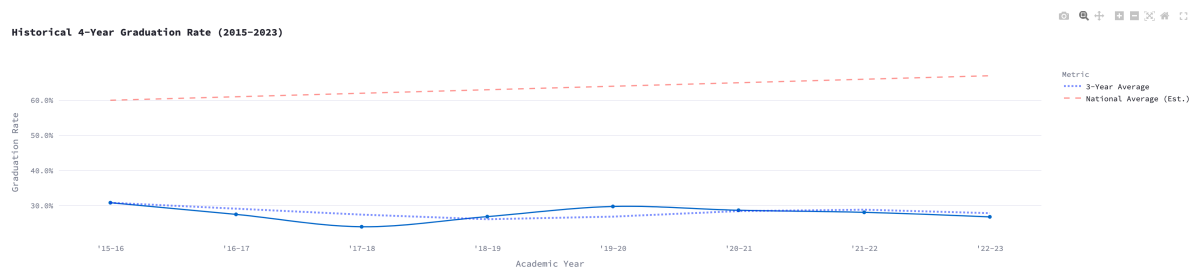


Average Net Price by Family Income

This visualization exemplifies Pathfinder's commitment to intuitive design, evidence-based insights, and cognitive accessibility. By breaking down net price by family income brackets and layering in reference points, it transforms abstract financial concepts into concrete, digestible insights. Additionally, I personally found it to be extremely useful: I explored universities I remember being interested in when I graduated high school, and discovered that some of those I discarded because I believed that they were financially unfeasible given my family's income, had in fact very reduced average net prices. To me, this visualization gives information to the student that is otherwise hard to find and comprehend, and does so with the following core design principles:

- **Effective Visual Encoding:** Bar length along a shared horizontal axis encodes net price values, in the sense that it ensures users can easily compare values across income groups without relying on numerical labels alone.
- **Redundant and Purposeful Use of Color:** Color is employed not to signal judgment but to distinguish categorical differences while maintaining a consistent aesthetic. This reinforces data groupings without introducing unintended evaluative signals—supporting Pathfinder’s broader design decision to avoid value-laden encodings.
- **Anchoring and Comparative Reference Points:** The horizontal red dashed line denoting the *Overall Average Net Price (\$14,559)* serves as a cognitive anchor. It supports comparative reasoning by helping users quickly assess whether a given income group experiences above- or below-average net costs. This guards against the anchoring bias, where users’ interpretations might otherwise be skewed by the first or most salient bar presented.
- **Cognitive Load Reduction and Interpretability:** The visual format converts complex financial data into an easily interpretable schema. Rather than relying on text-heavy tables or raw figures, the bar chart format offloads cognitive processing to the visual system—capitalizing on humans’ innate ability to detect relative magnitudes and spatial relationships. This design addresses the bounded capacity of working memory, facilitating faster and more confident decision-making.
- **Framing for Equity and Psychological Accessibility:** By showing *net* prices (rather than sticker prices) across socioeconomic segments, the visualization reframes cost in terms of actual affordability. This design combats the *framing effect*, a cognitive bias where initial impressions (e.g., high list prices) disproportionately influence perceptions. For lower-income students and families, seeing concrete evidence of price variation across income brackets can meaningfully shift perceived accessibility and promote more equitable exploration.

2. Historical 4-Year Graduation Rate Trend



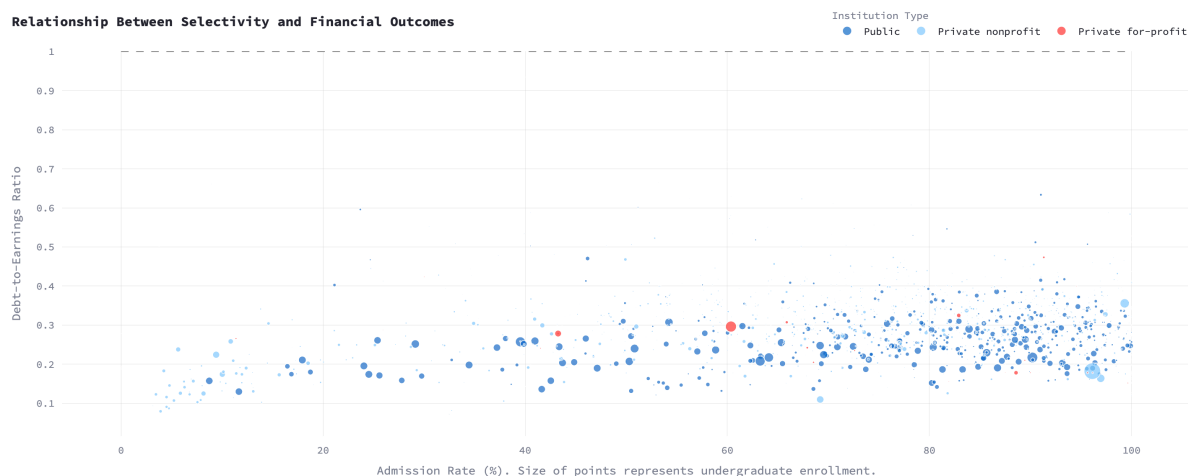
Historical 4-Year Graduation Rate Trend

This time-series visualization exemplifies Pathfinder’s commitment to temporal insight, contextual benchmarking, and pattern-oriented cognition. Through thoughtful encoding and narrative layering, it empowers users to understand institutional performance within both a temporal and comparative framework.

- Optimal Temporal Encoding:** The use of a line chart reflects best practices for time-series data, allowing users to intuitively track fluctuations and identify trends across academic years. The continuous horizontal timeline supports *temporal reasoning* by aligning with how users naturally conceptualize academic progression, thus reducing cognitive translation effort. Hence, indications of improving or worsening performance might be revealed.
- Dual-Layer Insight Structure:** By overlaying the raw data points (solid line with circular markers) atop a dotted *3-year rolling average*, the visualization achieves a balance between *granular accuracy* and *trend abstraction*. Users can both observe specific yearly values and grasp overarching patterns in performance.
- Comparative Benchmarking for Contextual Anchoring:** The addition of a dashed red line representing the *estimated national average* transforms the chart from a standalone institutional report into a comparative judgment tool. This contextual anchor allows users to evaluate not just whether graduation rates have improved or declined, but *how they compare to expected or normative performance*, enhancing the interpretive value of the data. Relative positioning of the institutional line against the national average fosters *relational reasoning*—one of the most effective cognitive tools for judgment. Rather than focusing on absolute scores, users are encouraged to make comparative assessments, which research shows are faster, more intuitive, and less error-prone.

- **High Data-Ink Ratio and Clarity:** The design adheres to Tufte's principle of maximizing the data-ink ratio: the chart avoids decorative excess and focuses on information-bearing elements—namely the trend lines, markers, and axis labels. This minimalist clarity supports faster pattern recognition and lowers cognitive load.
- **Pattern Recognition and Signal Amplification:** Our visual system is particularly well-suited to detect patterns in linear motion. By presenting the graduation rate data as a connected line, the visualization leverages this innate capacity for detecting directionality, slope, and inflection points. The 3-year rolling average further *amplifies signal over noise*, addressing the human tendency to over-interpret volatile or anomalous single-year deviations.

3. Admissions Rate vs. Debt-to-Earnings Ratio



Admissions Rate vs. Debt-to-Earnings Ratio

This multivariate scatterplot exemplifies Pathfinder's analytical depth and commitment to informed, bias-resistant exploration. By compactly encoding four variables—admission rate, debt-to-earnings ratio, institution type, and undergraduate enrollment—it delivers complex insight in a visually intuitive, cognitively manageable format.

- **Multivariate Encodings for Holistic Understanding:** This visualization applies Jacques Bertin's theory of visual variables to convey a dense matrix of information without overloading the user.

- **X-axis** encodes *admission rate (%)*—a proxy for selectivity.
- **Y-axis** encodes *debt-to-earnings ratio*—a composite measure of financial return.
- **Color** distinguishes *institution type* (public, private nonprofit, private for-profit).
- **Point size** reflects *undergraduate enrollment*, adding a sense of institutional scale.

This coordination of position, color, and size supports multivariate analysis in a clean, interpretable design.

- **Use of Meaningful Derived Metrics:** Rather than presenting raw debt and salary figures—which often obscure affordability—the chart introduces *debt-to-earnings ratio*, a synthesized, student-centered measure of return on investment. This transformation aligns with Pathfinder’s aim to reframe college evaluation in terms of *value for the student*, not prestige or price.
- **Reference Line for Interpretive Anchoring:** The inclusion of a horizontal dashed line at a 1.0 debt-to-earnings ratio serves as a cognitive anchor, signaling a critical threshold: a point where educational debt equals annual earnings. This contextual guide simplifies interpretation by helping users intuitively assess the *sustainability* of debt loads across institutions.
- **Alignment with Users' Mental Models:** The scatterplot supports users’ intuitive models: more selective institutions are often expected to yield better financial outcomes. Yet the visualization challenges this assumption by surfacing outliers and variability, such as less selective institutions with favorable debt outcomes, or for-profits with concerning ratios—prompting critical, nuanced interpretation over blind reputation-following. However, the design resists the cognitive trap of equating correlation with causation. By avoiding regression lines or oversimplified trend summaries, the visualization fosters exploratory insight while acknowledging the underlying complexity of higher education outcomes.

Conclusion

Pathfinder was built not simply to visualize data, but to enable better decisions. At its core lies a belief that prospective students—regardless of background—deserve access to transparent, contextual, and cognitively accessible information when navigating one of the most consequential choices of their academic lives. By applying principles of perceptual psychology, data visualization theory, and behavioral decision-making science, Pathfinder aims to elevate the quality and equity of the university selection process.

From progressive information disclosure to careful encoding strategies, every element of the interface was designed to reduce friction and bias while amplifying insight. Whether by transforming abstract financial data into intuitive bar charts, revealing institutional performance trends through time-series plots, or surfacing hidden patterns in multivariate scatterplots, I have to have built something that more or less begins to translate a very complex and disparate landscape into something more understandable.

I think of this project as decision-support system grounded in fairness, transparency, and trust. While this submission is institution-level in scope, the underlying philosophy is extensible. As the application evolves to include program-level insights, global institutions, and postgraduate data, these same principles will continue to guide its development: clarity over complexity and context over confusion.