Facets of Foams & Fibers

Contextualizing Materials and Measurements for the Restful ⅓ of Your Life

Abstract

The proliferation of online mattress-in-a-box companies has driven demand for continuous innovation in mattress materials and fabrication techniques in order to meet consumers’ preferences and diverse spending capacities. However, market competition among these direct-to-consumer brands has made it difficult for overwhelmed buyers to make effective purchasing decisions–Googling “best mattress” no longer yields an optimal, trustworthy path to checkout when hundreds of brands (and a continuous stream of new entrants) compete for your attention with seemingly identical (yet cleverly marketed) products sold from eerily similar online storefronts.

This project seeks to explore the range of physical materials, fabrication techniques, and construction methods found in mattresses across popular direct-to-consumer brands, linking the impact of these properties on consumer concerns including price, comfort, durability, and ecological footprint through an interactive data visualization.

The tool is meant to help prospective mattress buyers develop critical perspectives on materials through comparative analysis of mattresses within and across brands so they can make informed purchasing decisions no matter where they may land in the digital marketing maze.

Value System

Critical exploration of mattress materials/fabrication/construction and associated impact on one’s body, wallet, and the planet–revealing the invisible cross-section (e.g. relative comfort, durability, cost) while bypassing marketing hype. Wrestling asymmetric power away from the seller and reviewer–restoring power to the buyer. ***Transparency, Critical Inquiry, Trust***

From the Presentation:

“In noisy and polluted information environments, the bar for trust is set significantly high. To engender or restore trust, transparency is non-negotiable. This means inviting information-seekers to break beyond their funneled, context-deprived, linear information trails. Beyond scripted comparison shopping and non-choice architectures. An invitation to explore and understand how the parts announce the presence of a whole. And how the whole enables evaluation of the parts. For our purposes, we’ll need a better way to expose and explore the data encoded within mattress reviews. So that we might develop a critical lens on the ways in which physical materials, fabrication techniques, and construction methods meaningfully impact personal concerns including price, comfort, durability, and ecological footprint.”

Research Methods *(See Presentation for Supplemental Images)*

My initial research goal was to validate my hypothesis and show that information-seekers do indeed face noisy and polluted information environments that overwhelm effective decision-making when shopping for mattresses online.

To this end, I entered several well known direct-to-consumer mattress brands into Google Trends to understand search volume in relation to a query for “best mattress”, yielding a graph that charts the competitive and differentiated nature of the market.

Leveraging that signal, I move forward to validate that this competition manifests in Google Search results via paid ads and organic SEO. Refreshing searches for “mattress” yields a close race for the top spot as Casper, Nectar, Mattress Firm, and Wayfair shift in ranking. As I clicked through the direct-to-consumer mattress sites, it was clear that each was using eerily similar visual representations and copywriting strategies to market their mattresses–it wouldn’t be easy to get a clear and unbiased signal just by examining the material cross-sections when each site is incentivized to favorably describe their products.

To this end, I wanted to show that the noisy information environment extends to mattress reviews where we’d have hoped for objective, unbiased comparisons. Googling “best mattress” yielded a slew of review sites, with ads at the top linking to review sites which–upon further investigation–have conflicts of interest with the mattress companies (e.g. Casper had made financial investments into a secondary media company to buy a previously independent review site https://sleepopolis.com which ranks as the top ad and favors Casper mattresses). The layers of deception and misdirection in this information-seeking journey is mind-boggling!

Aside from the ads, there were still plenty of reliable sites (without the aforementioned conflicts of interest). Unfortunately, each served up a sizable list of “*best*s”, further validating that the search space is overwhelmed by sheer market saturation.

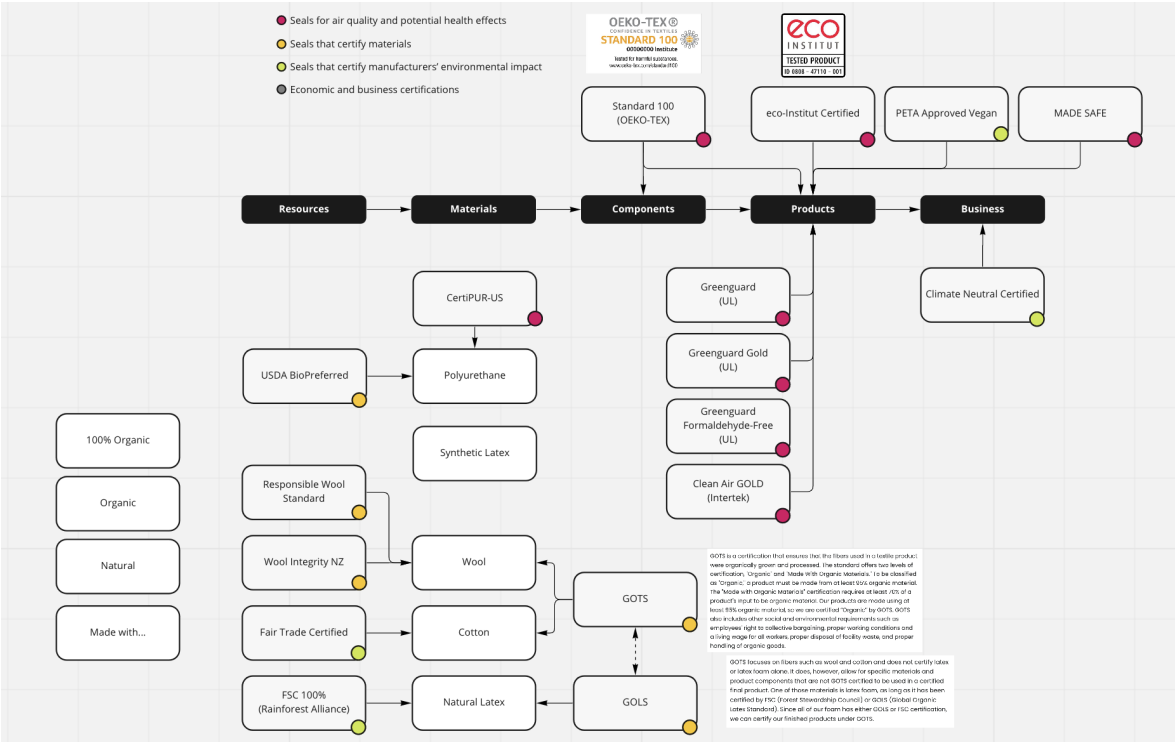
Perhaps some dimensions of “*best*” could be measured quantitatively? This was my next hypothesis that would help to cut through some of the noise and offer a more objective look at how the materials and measurements influence higher level concerns. Diving into https://sleepfoundation.org, I found a site that leveraged quantified measurements to rate mattresses along various dimensions of concern (e.g. bounce, motion transfer, heat management, etc). Though, I was still somewhat skeptical of the rating systems–scores were composed of both objective/quantitative data and subjective/qualitative claims without specifying the weight of the data vs. claim. At any rate, the measurements were not rendered visibly alongside each review on Sleep Foundation, so I had to seek out an alternate source that took a similar approach.

Landing on NapLab (“Objective, Data-Driven Mattress Reviews”), I managed to find what I was looking for in terms of a comprehensive dataset. Not only were systematic product testing measurements available alongside each review, but so were cutaway cross sections of each

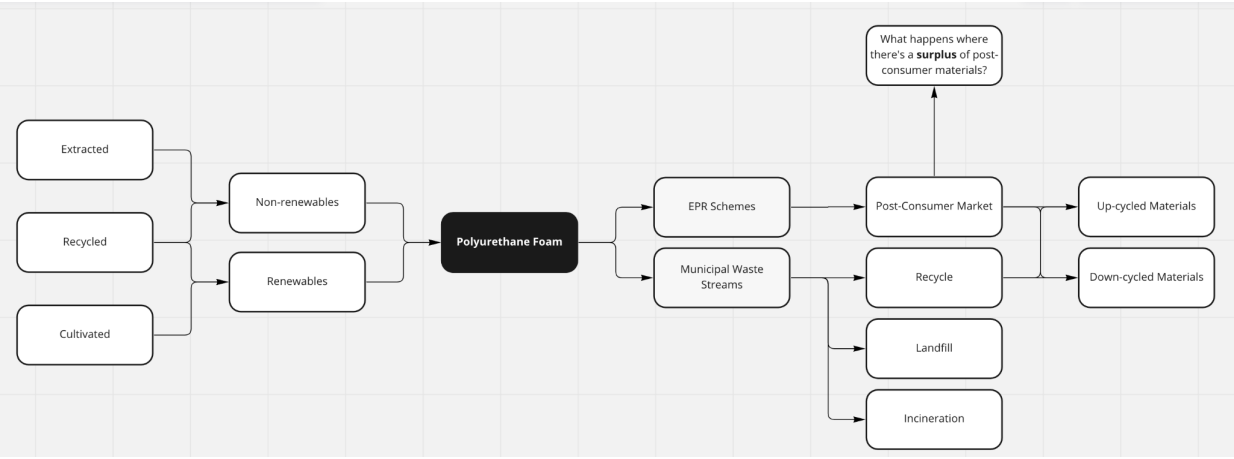
mattress, exposing the material layers and overall composition, further articulated in supplemental review text. This would allow me to link material composition to quantitative measurements (e.g. bounce, motion transfer, heat dissipation) with the goal of understanding how materials decisions contribute to higher level impact (comfort, price, etc).

With visibility into the material composition, I sought also to reveal the ecological footprint of each of the mattresses which could be computed in terms of embodied energy or durability. To this end, I collected material data (e.g. polyurethane foam, latex, cotton, wool, steel) from the Granta Design Database which could be use to derive the aforementioned values based on the material volume and density (though, it would be an estimate, as the specific measurable density is often not published by mattress sellers, nor known/listed by reviewers).

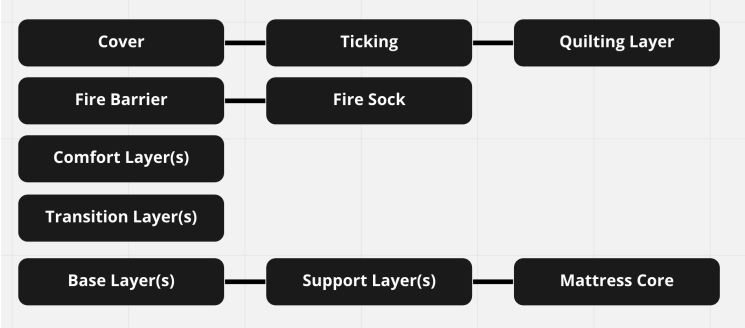
While engaging with the materiality of the mattresses, I found myself deep-diving into supply-chain certification schemes and industry standards for polyurethane, latex, cotton, and wool. This added another layer of complexity when evaluating a mattress, as brands proudly emphasize badges (e.g. safety standards, organic certifications, etc) alongside their products to generate trust, while prospective buyers may not be aware of the origins/affiliations of the certifying bodies, nor their differentiated levels of rigor. While I was unable to collect a full dataset and integrate this expanded range of concerns into the final visualization, I was able to gain critical perspective on supply-chain standards and transparency in the foam and textile industries. I even learned that there's a bio-based polyurethane foam incorporated into some mattresses, made with ~34% biomass (partially replacing petrochemicals)–a promising direction should this innovation gain additional traction through market mechanisms, improved material innovation, or regulatory intervention.



Supply Chain



Sources & End-of-Life

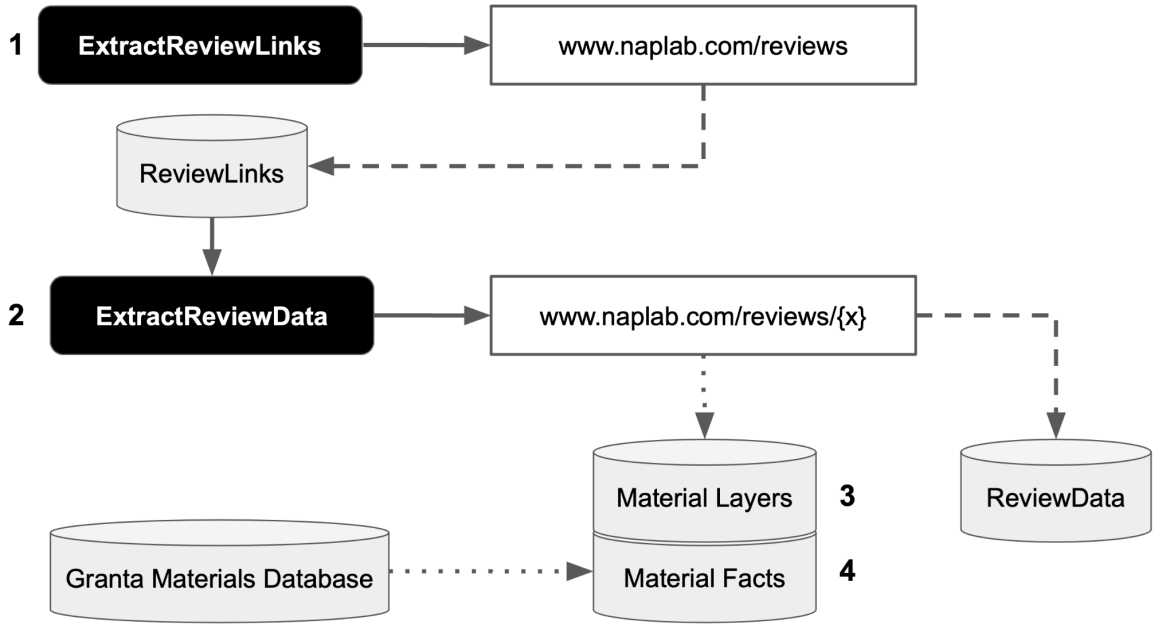


Structural Components

Data (Discovery/Structure/Acquisition/Cleaning)

I developed two web-scrapers to scrape 1) the list of mattress names and review links, and 2) the machine-readable review data from each link. Because there were ~100 links with reviews from different time periods–and with the occasional review for a two-sided mattress or other multi–review anomalies–there were some inconsistencies requiring manual intervention to make the review scraper more resilient to failure (e.g. skipping a whole review or individual field, adapting to consume data for a field from differently rendered components, etc). To this end, the final result set is closer to ~70 mattresses. The architectural diagram and data schemas follow:

Web Scraper & Data Architecture



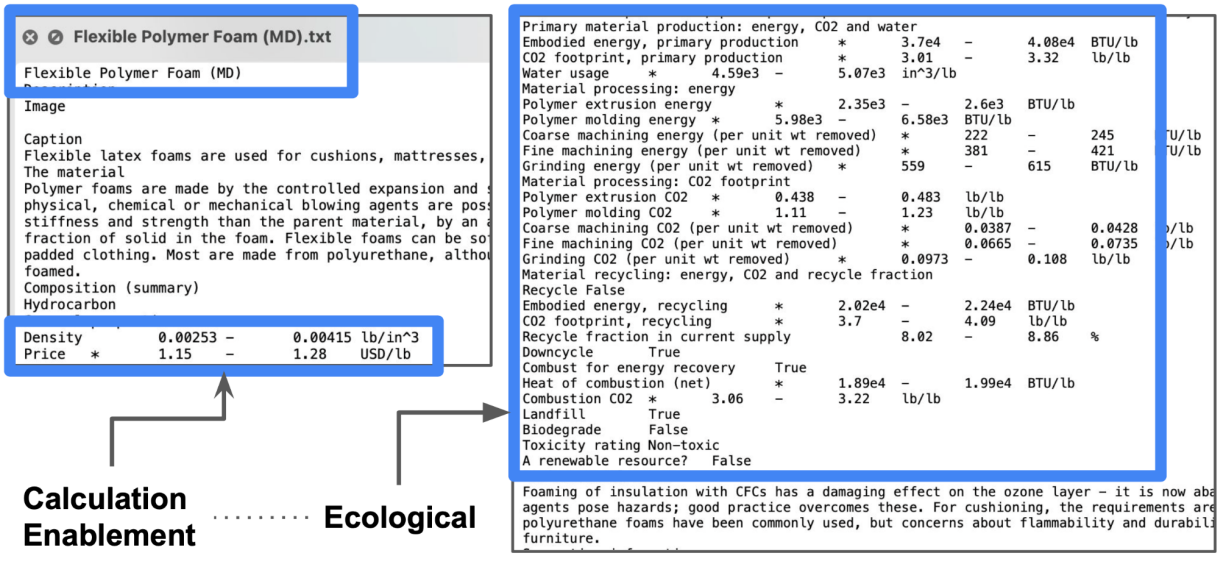
Product Review Data Schema (Example)


```
{
  "CATEGORY": "Natural & Organic",
  "MAKE_AND_MODEL": "Avocado Green",
  "PRICE": 1999,
  "REVIEW_URL": "https://naplab.com/mattress-reviews/avocado-mattress-review/",
  "FIRMNESS": 6.5,
  "FIRMNESS_GRANULAR": 6.5,
  "COOLING_tempBaseline": 81.2,
  "COOLING_tempMax": 90.5,
  "COOLING_tempFinal": 82.4,
  "COOLING_elapsedFinal": 5,
  "MOTION_TRANSFER_accelerationMax": 4.12,
  "MOTION_TRANSFER_accelerationMin": -3.19,
  "MOTION_TRANSFER_accelerationRange": 7.31,
  "RESPONSIVENESS_recoveredMostly": 0.3,
  "RESPONSIVENESS_recoveredCompletely": 0.7,
  "BOUNCE_maxDepth": 5.51,
  "BOUNCE_maxRebound": 6.03,
  "BOUNCE_totalBounce": 11.54,
  "EDGE_SUPPORT_maxSinkage": 3.25,
```

Material Layers Data Schema (Example)

```
{
  url: 'https://naplab.com/mattress-reviews/eluxury-mattress-review/#materials',
  layers: [
    {
      component: 'Cover',
      materials: [], // unspecified
      properties: ['thin', 'stretchy', 'breathable', 'taut'],
    },
    {
      description: 'Gel Memory Foam',
      primary: 'Memory Foam',
      additives: ['Gel'],
      properties: ['Cooling'],
      fabrication: ['Perforated'],
      component: 'Comfort',
      color: 'Blue',
      height: 3,
    },
    {
      primary: 'Poly Foam',
      fabrication: ['Convoluted'],
```

Granta Material Facts Example



Material Layers Granular Data Types (Additives, Primary, Fabrication, Component, etc)

```
// COVER ADDITIVES
// Cooling Fiber
// Cooling Gel

// PRIMARY
// Memory Foam
// Poly Foam
// Latex Foam (Natural)
// Latex Foam (Synthetic)
// Hyper-Elastic Polymer
// Pocketed Coils
// Support Coils

// ADDITIVES
// Gel
// Copper
// Graphene
// Graphite
// Wool
```

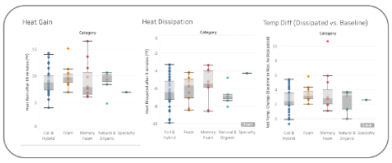
```
// FABRICATION
// Grid
// Convoluted
// Convoluted (Wide)
// Corrugated
// Perforated
// Air Bubbles
// Zoned Support
// Zoned Support (3)
// Zoned Support (7)
// Top 1/3
// Middle 1/3
// Bottom 1/3

// COMPONENT
// Comfort
// Support
```

Data Analysis (Initial)

Based on the matters of concern expressed across the individual mattress sites and review sites alike, I've generated a list of concerns that a prospective mattress buyer might want to know when evaluating whether a mattress might reasonably meet their needs. Using Tableau, I attempted to explore some commonly expressed trends (e.g. on average, coil/hybrid mattresses have a higher price and higher bounce, memory foam has improved motion isolation, latex mattresses sleep cool, etc) using the high-level categories from NapLab (before doing any further granular material disaggregation).

Your Body

Thermodynamics



Will I overheat or sweat?

- *Cover*
  - *Materials*
  - *Additives*
  - *Fabrication*
    - *Quilted*
    - *Pillow Top*
- *Layers*
  - *Coils? Y | N*
  - *Memory | Poly | Latex | ...*
  - *Additives?*
    - *Gel | Copper | Graphene | ...*
  - *Fabrication*
    - *Grid*
    - *Perforated*
    - *Convoluted*
    - *Corrugated*
    - *Perforated*
    - *Air Bubbles*

Kinematics

Will my partner be bothered if I move? (undesired case)

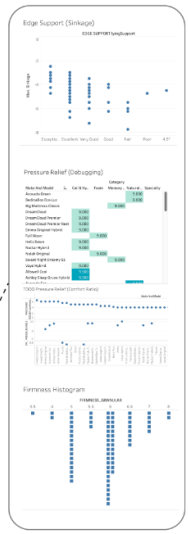
Will I be able to know if my partner/kids/pets are moving? (desired case)

Will our mattress distract from or enhance play?

Will I feel "stuck" in the mattress?

- *Cover*
  - *Materials*
  - *Fabrication*
    - *Quilted*
    - *Pillow Top*
- *Layers*
  - *Coils? Y | N*
  - ~~*Memory | Poly | Latex | ...*~~
  - *Comfort Height*

Support & Feel



Will we feel like we fit comfortably? (e.g. partner/kids/pets)

Experiencing Support:

- *Will I avoid pressure points?*
- *Will I have proper spinal alignment?*

Choosing Firmness:

- *Sleep Position*
- *Body Weight*
- *Personal Preference ("Feel")*

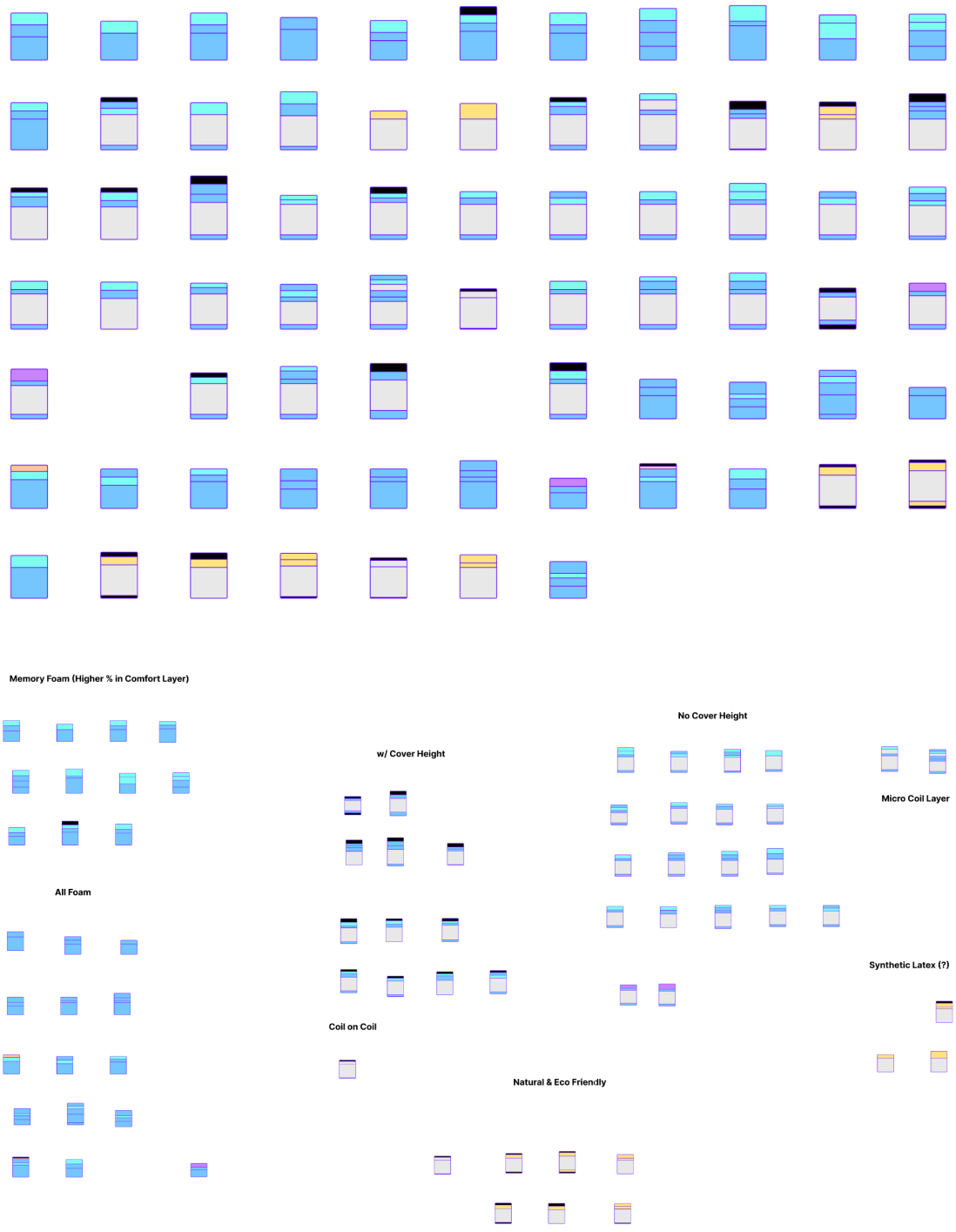
Sinkage
(TODO)

Excessive sinkage, deeper-than-desired contour can lead to pressure-relief issues.

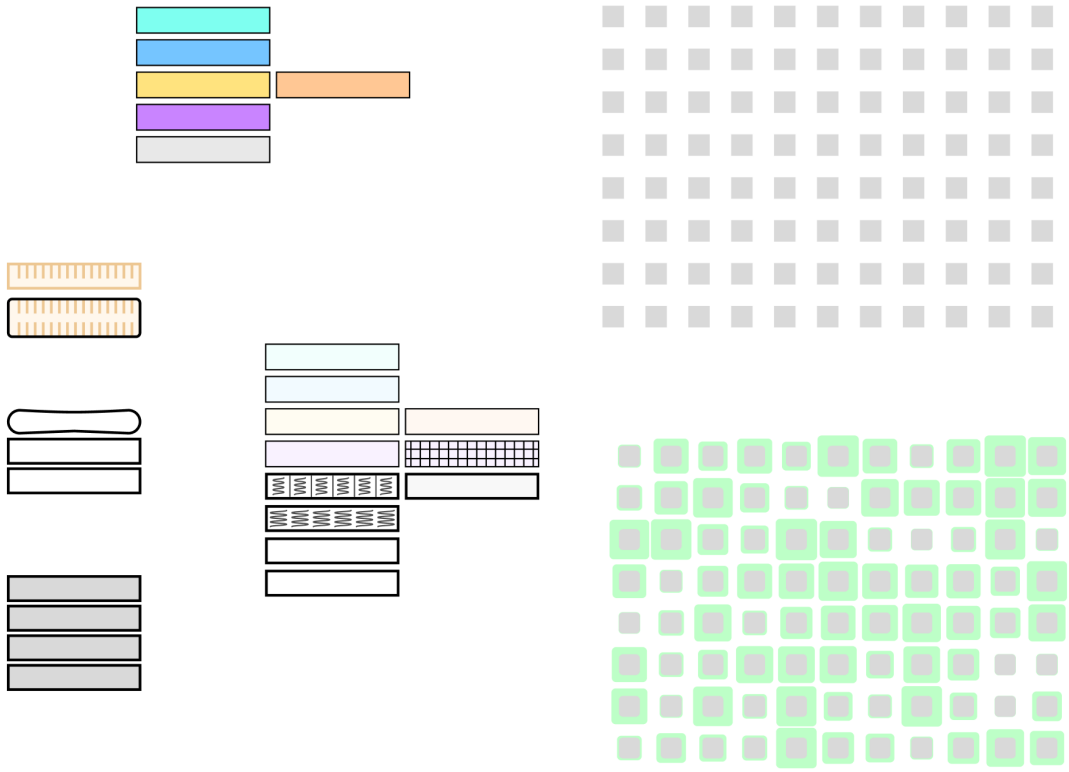
More material touching body can lead to overheating

Representation

Mapping the different layer materials to colors and proportional heights, I managed to represent all of the mattresses from the dataset.



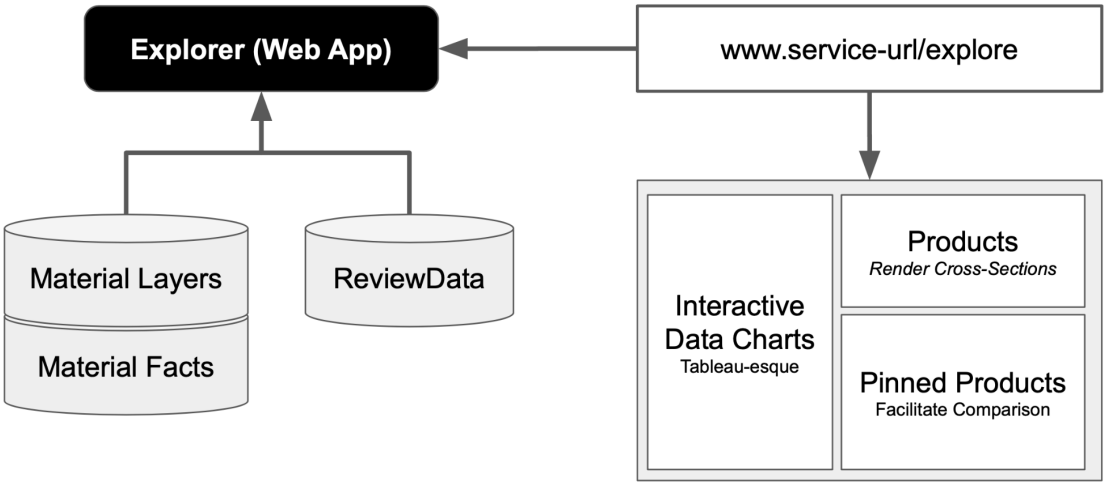
Manual Clustering for Visual Inspection



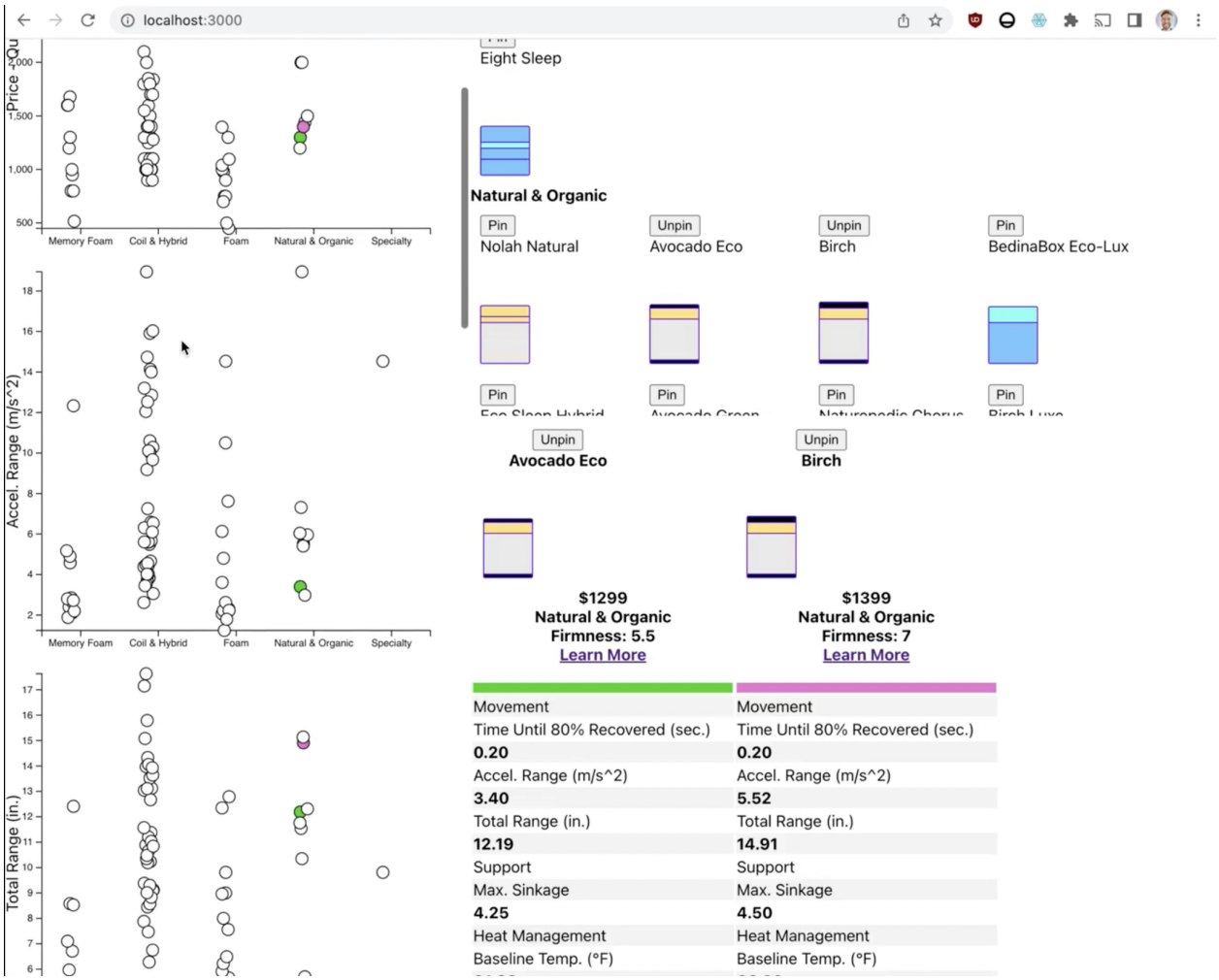
Exploratory Iterations (not pictured in final visualization)

Data Visualization (Architecture)

I've exposed the material layers and quantitative review data in a React app, combining the Tableau-like chart representations for each measure alongside the material cross-sections pinnable for persistent comparison.



Equipped with an interactive data visualization consisting of the data scraped from the mattress review site–material layers and quantitative measurements–(and embodied energy in a future iteration), users may explore the degree to which materials may or may not influence higher level mattress characteristics including comfort, price, and ecological footprint–compactly contextualized against *all mattresses* (which wasn't possible on individual brand sites, nor on review sites which only made room for 1:1 comparisons along specific *subjectively-informed* ratings).



Reflection

Learning

Content - Textile Ecologies

Having practically zero exposure to physical/material research and analysis in my career/schooling aside from the preterm work this year, I've gained an appreciation for previously overlooked concerns surrounding materiality–what materials are involved in a manufactured product, where/how they're sourced, what happens at the end-of-life, various interventions and innovations to yield more ecologically friendly (and less chemically harmful) outcomes, their resulting physical properties/characteristics, and *how challenging it can be to rollup these concerns into neatly packaged higher-level evaluations* (such as "comfort" and "heat management") in the context of multi-material products that interact with the human body.

Diving deep into this world, I learned about the various certifying agencies, standards, and certification levels involved in producing quality textiles (e.g. GOTS for organic cotton/wool, GOLS for organic latex, OEKO-TEX for harmful substance testing, USDA BioPreferred, etc) and which aspects of the supply-chain and product components are covered under these schemes. I've therefore developed a more discerning perspective to spot greenwashing–and have started considering better approaches to transparency for certifications (and a potential web-based platform to easily and transparently link to these certifications upstream from customer-facing sites).

Skills, Process, Methods

I've greatly sharpened my web-crawling abilities. While I've used Selenium-based tools for frontend testing professionally, I've never scraped a site for data collection and analysis. Due to the inconsistent nature of the site, I learned to encode resilience into the scraper so that it would fail gracefully, and I could quarantine/debug specific failures after getting through the bulk of the reviews.

I was glad to have briefly explored the Granta material database–as someone unfamiliar with material science, it feels reassuring to have a reliable source so that I can feel confident learning more and making use of the material properties and measurements available.

I only briefly used Tableau during the preterm, but found it to be a really useful first-pass at exploring the initial dataset. The grouping, filtering, and multi-dimensional/categorical charts helped me to efficiently validate preliminary hypotheses (e.g. cross-category pricing, bounce, motion transfer, etc) before diving into more granular exploration. I'd like to learn to add additional data sources (e.g. multiple data tables so that I may have explored quantitative measurements by lower-level material facets such as additives, fabrication, and components).

While I found myself deeply engaged in the investigative approach to this project which could be dissected in a plurality of ways (perhaps at the expense of more a stratford data analysis), I eventually discovered a set of quantitative dimensions which would prove useful in the analysis. Through this process, I have learned that while something might be interesting and worthy of exploration, it might not necessarily be the appropriate data representation for performing an effective analysis (for example, I could have produced a visualization using the review site data without ever having spent time deep-diving into ad rankings, individual brand websites, and fake review sites–though, that exploration added significant context and motivation for the project). Through this circulare stumbling, I feel more equipped to notice when I have a proper anchor or am chasing a distraction in future projects.

While my final visualization could have benefitted from additional time and consideration, I was able to explore D3 more pragmatically and holistically–brushing up against version differences along the way that required deeper comprehension of the API (e.g. examples I was referencing were in V4, but locally I was running V6 which meant I needed to more deeply understand the API to reliably migrate the code). D3 seems to be a practice, practice, practice sort of tool–this was a great initial start to getting to know it a bit better.

Self Evaluation (Final Project & Review)

The final data visualization is functionally and graphically incomplete, with the full range of functionality still somewhat undecided/unknown due to the complexity of what's being measured (e.g. temperature Δ, acceleration range, sinkage depth) versus the higher-level aggregate subjective measures (e.g. "comfort", "cooling", "pressure relief", etc)–there is no 1:1 mapping from objective to subjective, which is what makes this dataset so tricky. While an intention exists to enable more granular data perspectives (e.g. group by material fabrication, material additives, material components, cover materials/composition; sort by computed value), this is not visually represented in the UI. The overall canvas is currently distracting–too many functions are shown at once; drill-downs and on-demand context might help reduce the noise. Perhaps encoding secondary/tertiary dimensions on the scatterplot dots could help enrich meaning in a compact form. Graphical core and refinements (font, color, lines, composition, etc) are not expressed in this prototype. Additionally, while the data is readily available in the code, the material names/additives/fabrications have not been rendered (directly on the mattress, in a tooltip, or otherwise).

However, this interface is scaffolded atop a comprehensive architectural core as represented in the presentation slides. From resilient data crawling and transformation, to a well-structured React application composed of reusable components and shared utilities, the D3-powered web app effectively integrates multiple data sources into a unified system with multiple rendered outputs (scatter plot, tabular, visual layering), demonstrating an ability to effectively map data points between representation spaces, and with a clear direction of how to conceal, reveal, and transform various aspects of the data.

Leveraging this technical core, the most important aspect is fully wired up as a proof-of-concept: when products are pinned for comparison, the respective data points are highlighted (via color-coding) across each of the scatter plots so that the user can understand how the products relate to each other contextualized against all other products–this addresses a critical aim of the project: helping users properly anchor their understanding *relative to the whole* (otherwise impossible within the funneled, context-deprived, linear information trails from our Google searches and review site traversals).

Because what we really wish to know are the answers to the questions posed in relation to the mattress (e.g. “Will I overheat?”, “Will my partner be bothered if I move?”, etc) it would have been powerful to determine which of the facets of the foam have greater influence on these characteristics (or surprisingly little influence), and then trace through the scenarios, drilling down into the data to make that discovery and reveal that to the project reviewers. It would also do the heavy lifting of showing what we can and cannot discern given the data from the review site–showing where marketing speak breaks down and no significant quantifiable difference persists.

Regardless, this project demonstrates ambition for engaging with an opaque and deceptive industry–attempting to expose not only the material cross section, but the invisible cross-sections as well (how it impacts the body, wallet, and planet). In the process, potentially surfacing the flimsy, inflated ratings of professional mattress reviews (e.g. only ever giving an 8.5-9.8 on a 1-10 scale while concealing that true range). Or that maybe cooling gel doesn’t actually make a real difference? The intention of wrestling power back from asymmetrically powerful mattress reviewers and mattress brands. And attempting to wrangle together some material truths that can’t be brushed over with flowery language. The final project doesn’t necessarily stick the landing, but it has legs, a spine, and a brain–with a bit more time maybe it would have even had a mouth to speak something powerful.