Data Driven Design Decisions

May 2015
Overview

• About MKThink

• Why Use Data?

• Analysis Process

• Example 1: Arlington Public Schools Occupancy and Utilization

• Example 2: San Francisco Unified School District School Lunch Supply Chain

• Example 3 Hawai‘i Department of Education Energy Systems Study
Why Use Data?

1. Data can be used to simplify and model complex systems.

2. Data can reveal patterns and can be used to do comparative analysis.

3. Data can help us make better decisions based on proof.
New Websites

570
New websites are created every minute.

820,800
New websites are created every day.

299,592,000
New websites are created every year.

Bernard Marr, CEO Advanced Performance Institute, 2014.
Data Centers

6,000

Number of football fields equivalent to the area of all the world’s data centers.

7,920

Number of acres of land used to house all the world’s data centers.

345,600,000

Square feet of building space dedicated to all the world’s data centers.

Bernard Marr, CEO Advanced Performance Institute, 2014.
Digital Universe

70,000,000,000,000,000,000,000

Rough estimate of the number of stars in the observable universe.

82,000,000,000,000,000,000,000

Number of Bits of information stored in the digital universe.

Bernard Marr, CEO Advanced Performance Institute, 2014.
Digital Breadcrumbs

204,000,000
Emails sent every minute.

1,800,000
Facebook likes every minute.

278,000
Tweets sent every minute.

Bernard Marr, CEO Advanced Performance Institute, 2014.
Projected Growth of Data

Global Data (in zettabytes)

1 zettabyte = 1,000,000,000,000 gigabytes

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Signal or Noise?

“There isn’t any more truth in the world than there was before the Internet or the printing press. Most of the data is just noise, as most of the universe is filled with empty space.”

_Nate Silver_

Central Challenge

How can we *harness data* and *cut through the noise*, to help us *make better decisions* about facilities planning and capital investments?
Ask the Right Question

• In order to get to the best solution, it is imperative to start by asking the right question.

• Sometimes our clients already have a question in mind, but sometimes we need to work with them to adjust the focus and/or intent of the question.
Create Analytical Framework

- Identify all the important components of the system in question and define the relationships between system components.
- Analytic framework is based off of system model and is the structure for relational database.
- Developing the analytic framework is a *qualitative, design exercise*.
Identify Necessary Data

1. Identify data points necessary to define the system components
2. Identify authoritative data sources
3. Determine appropriate collection methods

- Self Reported
  - Focus Groups
  - Interviews
  - Surveys
  - Observation
  - Instrumentation

- Objective Collection

develop analytic framework
collect relevant data
Right Analysis
Right Data

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Run Analysis

1. **Right Question**
   - Develop analytic framework

2. **Right Data**
   - Collect relevant data

3. **Right Analysis**
   - Run data analysis

4. **Run analysis on collected data using analytical framework**
   - Scrub and format datasets
   - Enter datasets into relational database and flesh out data model
Answer Question

1. Right Question
   - Identify opportunity set

2. Right Data
   - Collect relevant data

3. Right Analysis
   - Run data analysis

4. Right Decisions
   - Develop analytic framework

5. • Identify key findings from data analysis
   • Reflect on original question based off of key findings and initial conclusions
   • Develop a set of options or scenarios to respond to the question at hand
   • Identify tradeoffs for each option by testing sensitivity of variables
Examples

Finding the Right Question:
Arlington Public Schools
Occupancy and Utilization

Building a System Model:
San Francisco Unified School District
Supply Chain Consolidation

Collecting the Right Data:
Hawai‘i Department of Education
Thermal Comfort and Heat Abatement Research
Asking the Right Question

Arlington Public Schools
Occuancy and Utilization
Project Context
Arlington Public Schools

- 13th Largest school system in Virginia
- 2013-14 Enrollment was 23,316 students
- Enrollment has grown by 3,782 students since 2008, and average of 3.8% per year
- Enrollment is projected to grow by another 3,300 students by 2018-19 school year
- Increase in enrollment will affect all grade levels but will have the greatest impact on high schools
Asking the Right Question

Arlington Public Schools

Data Seen By Client:
Census Projections
Enrollment Projections

Original Question:
“Where should we build a new building?”

Data Seen By Client:
Real Estate Availability
Classroom Loading
Facility Capacity

Modified Question:
“How might we better utilize our existing buildings?”
Developing Analysis
Arlington Public Schools

- Identified all the aspects affecting occupancy and utilization for APS middle and high schools
- Determined which components were important to model
Data Collection
Arlington Public Schools

- Collected classroom scheduling data, classroom occupancy per period, and facilities level data to assess occupancy and utilization
- Overlaid all analysis on facilities floor plans to understand how occupancy changes spatially over time

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Occupancy Analysis

Arlington Public Schools

- Developed data model to describe the components defined in system/supply chain model
- Evaluated various scenarios based on model inputs and assumptions

Weekly Room Use Hours By Room Type
Recommendations

Arlington Public Schools

- Utilize unscheduled spaces to increase capacity at peak periods of the day

- Further develop and utilize professional learning centers (PLCs) to have teachers share classrooms and increase capacity, occupancy, and utilization of classrooms across the district

- Do not build a new building prior to attempting to optimize classroom occupancy through operational changes
Building a System Model

San Francisco Unified School District
Supply Chain Consolidation
Project Context
San Francisco Unified School District

- Student Nutritional Services Division engaged with IDEO to develop design recommendations to improve the school food experience

- SFUSD currently serves 10,170 meals per day, capturing about 40% participation of enrolled students

- Visited 105 school sites to inventory kitchen and dining facilities and equipment

- Developed scenario model to test viability of regional and central kitchen strategies
Asking the Right Question
San Francisco Unified School District

Data Seen By Client:
IDEO Design Recommendations
Design Solution Financial Model

Original Question:
“Where should we build three regional kitchens?”

Data Seen By Client:
Operations/Supply Chain
Facilities Data

Modified Question:
“Where should we build three regional kitchens, or one central kitchen?”
Building a System Model
San Francisco Unified

• Worked with district staff to develop a system model of the district's food supply chain and meal production system

• Identified datasets relevant to each component of the supply chain and started filling in the information with existing data

• Defined approach for collecting all remaining data points
Data Collection
San Francisco Unified School District

- Digitized data collection forms to streamline collection process
- Dispatched data collection teams to 105 school sites to assess and record equipment and facilities data
Modeling and Analysis
San Francisco Unified School District

- Developed data model to describe the components defined in system/supply chain model
- Set assumptions for unknown or projected variables
- Evaluated various scenarios using key metrics
Modeling and Analysis
San Francisco Unified School District

Model Inputs and Assumptions

Model Sensitivities

- Defined model assumptions with client to team assure alignment with SNS and district goals
- Determined sensitivities of various model parameters
Recommendations
San Francisco Unified School District

- Assessed value of various scenarios over a ten year time period
- Used model results to recommend the development of a phased regional kitchen strategy or a single central kitchen strategy
Collecting the Right Data

Hawai‘i Department of Education

Thermal Comfort and Heat Abatement Research
Project Context
Hawai‘i Department of Education

- Collect data pertaining to building assets, energy usage, comfort level, and financials from the Campbell, Ilima, Kaimiloa, and Pohakea campuses through field installed instrumentation and on-site observation.

- Identify opportunities for improvements in energy consumption, comfort levels, and overall economics associated with comfortable learning environments.

- Develop various scenarios and options through to create a draft strategic plan to guide future physical building modifications.
Asking the Right Question
Hawai‘i Department of Education

Data Seen By Client:
Feedback from students, families, and teachers
Temperature Data

Original Question:
“Students are uncomfortable so we need to lower the temperature so we need air conditioning, how are we going to pay for it?”

Data Seen By Client:
Fuel/Operating Costs
Installation Costs

Modified Question:
“Students are uncomfortable, how do we improve thermal comfort?”
Building System Model
Hawai‘i Department of Education

- Defined asset, resource, and cultural variables associated with Thermal Comfort
- Mapped the relationships between variables
Collecting Relevant Data
Hawai‘i Department of Education

Site Attributes:
- Surrounding Ground Material
  - % Grass
  - % Dirt
  - % Paving: Concrete
  - % Paving: Asphalt
  - % Shaded by Trees
  - % Shaded By Other

Building Level Attributes:
- Building Orientation
- Roof Color
- Façade Orientation
- Floor Level
- Construction Material
- Building Color

Façade Attributes:
- % of Fenestration
  - % Operable
  - % Glazing
  - % Louver
  - % Other
- Window Type
- Location of Windows
- Depth of Overhang
Collecting Relevant Data
Hawai‘i Department of Education

Interior Environment:
- Temperature
- Mean Radiant Temperature
- Relative Humidity
- Illuminance
- CO₂ Levels
- Sound

Air Quality:
- CO₂
- CO
- NO₂

Energy Monitoring:
- Wattnode
- Pulse
- Current

Outdoor Environment:
- Temperature
- Relative Humidity
- Wind Speed / Direction

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Data Analysis
Hawai‘i Department of Education

• Compare Asset, Resource, and Cultural datasets across all monitored classrooms

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## Data Analysis

### Hawai’i Department of Education

<table>
<thead>
<tr>
<th>Room O102</th>
<th>Room O104</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orientation</strong></td>
<td>SE</td>
</tr>
<tr>
<td><strong>% Fenestration</strong></td>
<td>25%</td>
</tr>
<tr>
<td>% Operable</td>
<td>100%</td>
</tr>
<tr>
<td>% Glazing</td>
<td>-</td>
</tr>
<tr>
<td>% Louver</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Windows Type</strong></td>
<td>Ribbon</td>
</tr>
<tr>
<td><strong>Depth of Overhang</strong></td>
<td>8’</td>
</tr>
<tr>
<td><strong>Ground Material</strong></td>
<td>Asphalt</td>
</tr>
<tr>
<td>% Grass</td>
<td>5%</td>
</tr>
<tr>
<td>% Dirt</td>
<td>5%</td>
</tr>
<tr>
<td>% Concrete</td>
<td>-</td>
</tr>
<tr>
<td>% Asphalt</td>
<td>90%</td>
</tr>
</tbody>
</table>

- Isolate specific attributes by identifying similar classrooms

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Assess the affects of isolated attributes on interior classroom environments and on the perceptions of thermal comfort by classroom occupants.
Recommendations
Hawai‘i Department of Education

• Design, implement, test, and evaluate the effectiveness (both cost- and technical effectiveness) of passive and mechanical heat abatement and increased ventilation strategies (e.g. nocturnal flushing, white roofs, mechanical cooling, sun shading, etc.)

• Measure the change in interior environments and the change in perceptions of thermal comfort as related to each implemented strategy

• Develop a system-wide thermal comfort master plan to determine which strategies to deploy at which buildings at which school sites