The Stem House

Structures—Team 2

Engineering Design 100 Section 17
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Thursday, October 17, 2013
Table of Contents

- The Task
- The Approach
- The Evaluation
- The Analysis
- The Model
- Conclusions
- Project Management
Problem Statement: The United States is falling down the rankings in educating students in the science and math disciplines. Our task is to attempt to solve this problem by making a “STEM House” to excite and encourage students in the STEM disciplines.
The Task

- Mission Statement: To design and build an educational tool to be marketed and sold to middle schools in order to motivate and assist in educating students in grades 6-8 in the STEM disciplines, using structures as a subsystem while interfacing with other subsystems.
The Task

- **Customer Needs:**
  - **Stakeholders:**
    - School Board
    - Parents
    - Teachers/Principals/Staff
    - Students
  - **Obtainable:**
    - Parents
    - Teachers
    - Students
The Task

Customer Needs Assessment:

- Do you think this system is beneficial to students? How?
- How much are you willing to spend for this program?
- How do you think parents will respond to the idea?
- How comfortable are you teaching these topics?
- What type of structure would you like this facility to be?
- How much physical space would you be willing to give up for this program?
The Task

- Specifications:
  - Virtual combined with interactive learning
  - Ability to fit into a classroom
  - Easily assembled
  - Able to be mass produced
  - Under $100
  - Must encourage and maintain at least 40 students
  - Must satisfy Pennsylvania State Educational Standards
Design Process

- Brainstorming
  - Strengthening structures
  - Bridges and towers
  - Forces and momentum
  - Volume vs. Surface area
  - Buoyancy
  - Vibrations
  - Simple machines
  - Vectors
  - Design Process
Fig. 1. Systems Diagram
Fig. 2. Objective Tree

- Marketable
  - Inexpensive
  - Adaptable
    - Easy to assemble
    - Able to fit in a room
  - Useful
    - Extracurricular activity
    - Aid teachers
  - Durable
- Educational
  - Teach academic standards
  - Interactive
    - Virtual
    - Hands-on
  - Motivating
Fig. 3. Weighted Objective Tree

Structures Panel
1.0 | 1.0

Marketable
0.55 | 0.55

Inexpensive
0.2 | 0.11

Adaptable
0.35 | 0.193

Useful
0.35 | 0.193

Easy to assemble
0.3 | 0.058

Able to fit in a room
0.7 | 0.135

Aid teachers
0.5 | 0.097

Educational
0.45 | 0.45

Teach academic standards
0.33 | 0.149

Virtual
0.4 | 0.060

Hands-on
0.6 | 0.089

Durable
0.10 | 0.083

Motivating
0.33 | 0.149

Interactive
0.33 | 0.149

Extracurricular activity
0.5 | 0.097
## Evaluation

Table 1. Design Matrix

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Bridges</th>
<th>Tower</th>
<th>Spring</th>
<th>Volume vs. Surface area</th>
<th>Pulley</th>
<th>Buoyancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ease of use</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>-</td>
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<tr>
<td>Ease of assembly</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pennsylvania State Standard</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
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<tr>
<td>Interactive</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Pluses</td>
<td>4</td>
<td>4</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>Sames</td>
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<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Minuses</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>2</td>
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<tr>
<td>Net</td>
<td>4</td>
<td>4</td>
<td>-2</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Rank</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>5</td>
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<tr>
<td>Continue</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
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</table>
### Evaluation

#### Table 2. Pairwise Comparison

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Row totals</th>
<th>Row total/total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>13</td>
<td>0.3805</td>
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<tr>
<td>B</td>
<td>1/2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>6.5</td>
<td>0.1902</td>
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<tr>
<td>C</td>
<td>1/2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1 1/2</td>
<td>5</td>
<td>0.1463</td>
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<tr>
<td>D</td>
<td>1/2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>7.5</td>
<td>0.2195</td>
</tr>
<tr>
<td>E</td>
<td>1/6</td>
<td>1/3</td>
<td>1/3</td>
<td>1/3</td>
<td>1</td>
<td>2.167</td>
<td>0.0634</td>
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</table>

A- Cost
B- Ease of Use
C- Pennsylvania State Standard
D- Ease of Understanding
E- Interactive

Total: 34.167
### Table 3. Cost Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Cost ($)</th>
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<tbody>
<tr>
<td>Shapes</td>
<td>21.47</td>
</tr>
<tr>
<td>Toothpicks</td>
<td>4.00</td>
</tr>
<tr>
<td>Glue</td>
<td>15.30</td>
</tr>
<tr>
<td>Pulley</td>
<td>12.41</td>
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<tr>
<td>String</td>
<td>4.00</td>
</tr>
<tr>
<td>Weights</td>
<td>23.75</td>
</tr>
<tr>
<td>Panel</td>
<td>9.00</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>89.93</strong></td>
</tr>
</tbody>
</table>
The Model

Fig. 4. Image of Prototype
The Model

Fig. 5. Image of Prototype
The Model

Fig. 6. Image of Prototype
Pennsylvania State Standards
2.3.8.B. Develop strategies for determining areas and volumes of compound shapes and solids.

2.3.8.C. Calculate volume, surface area, and degrees of angles; calculate circumference and area of circles.

2.9.8.A. Name, describe and apply geometric relations for 1-dimensional shapes and 2-dimensional shapes and 3-dimensional solids.
3.2.7.B1. Describe how unbalanced forces acting on an object change its velocity. Analyze how observations of displacement, velocity, and acceleration provide necessary and sufficient evidence for the existence of forces.

3.4.6.E7.
Explain how the type of structure determines the way the parts are put together
Conclusions

- Using the design process, we were able to create a sophisticated teaching tool.
- To best form a project, ideas need to be taken from every stakeholder.
- Engineering is far more than just math and science. It requires far more extensive subjects in order to handle the marketing and project development aspects of every project.
# Project Management

## Define

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine the customer need</td>
<td>Andrew</td>
<td>2 days</td>
<td>Fri 9/13/13</td>
<td>Mon 9/16/13</td>
</tr>
<tr>
<td>Search the literature for any regulatory requirements</td>
<td>Jim</td>
<td>2 days</td>
<td>Fri 9/13/13</td>
<td>Mon</td>
</tr>
<tr>
<td>Find and research similar products</td>
<td>Ramon</td>
<td>2 days</td>
<td>Tue 9/17/13</td>
<td>Wed</td>
</tr>
<tr>
<td>Identify stakeholders</td>
<td>Maxine</td>
<td>2 days</td>
<td>Tue 9/17/13</td>
<td>Wed</td>
</tr>
<tr>
<td>Interview stakeholders</td>
<td>Andrew</td>
<td>2 days</td>
<td>Tue 9/17/13</td>
<td>Wed</td>
</tr>
<tr>
<td>Obtain specifications</td>
<td>Jim</td>
<td>2 days</td>
<td>Wed 9/18/13</td>
<td>Thu 9/19/13</td>
</tr>
<tr>
<td>Revise problem statement</td>
<td>All</td>
<td>3 days</td>
<td>Tue 9/17/13</td>
<td>Thu 9/19/13</td>
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</tbody>
</table>

## Generate concepts

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brainstorm ideas</td>
<td>All</td>
<td>4 days</td>
<td>Tue 9/17/13</td>
<td>Fri 9/20/13</td>
</tr>
<tr>
<td>Create pairwise comparison and weighted matrix</td>
<td>All</td>
<td>2 days</td>
<td>Sat 9/21/13</td>
<td>Mon 9/23/13</td>
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</table>

## Select promising concept(s)

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>All</td>
<td>3 days</td>
<td>Sun 9/22/13</td>
<td>Tue 9/24/13</td>
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## Begin Detailed Design

<table>
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<tr>
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<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform detailed analyses of concepts</td>
<td>Andrew</td>
<td>4 days</td>
<td>Mon 9/23/13</td>
<td>Thu 9/26/13</td>
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</tbody>
</table>

## Material selection/availability

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jim</td>
<td></td>
<td>3 days</td>
<td>Sun 9/29/13</td>
<td>Tue 10/1/13</td>
</tr>
</tbody>
</table>

## Component selection/availability

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxine</td>
<td></td>
<td>2 days</td>
<td>Tue 10/1/13</td>
<td>Wed 10/2/13</td>
</tr>
</tbody>
</table>

## Sketchup drawing

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew</td>
<td></td>
<td>5 days</td>
<td>Tue 10/1/13</td>
<td>Mon 10/6/13</td>
</tr>
</tbody>
</table>

## Cost estimation

<table>
<thead>
<tr>
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<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramon</td>
<td></td>
<td>1 day</td>
<td>Tue 10/1/13</td>
<td>Mon 10/2/13</td>
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## Documentation and Reporting

<table>
<thead>
<tr>
<th>Task</th>
<th>Responsible</th>
<th>Duration</th>
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<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of first progress report</td>
<td>All</td>
<td>2 days</td>
<td>Fri 10/11/13</td>
<td>Mon 10/14/13</td>
</tr>
</tbody>
</table>

## Preparation of second progress report                    | All         | 1 day    | Mon 10/14/13| Mon 10/15/13|

## Preparation of final report                             | All         | 1 day    | Tue 10/15/13| Tue 10/16/13|

## Preparation of final presentation (powerpoint)           | All         | 1 day    | Wed 10/16/13| Wed 10/17/13|

## Refine the project as needed                             | All         | 1 day    | Thu 10/17/13| Thu 10/18/13|

Table 4. Gantt Chart
References

- [http://www.homedepot.com/c/Featured_At_Home_Depot](http://www.homedepot.com/c/Featured_At_Home_Depot)
- David Farrell, Millburn High School
- Donald Coughlan, Board Member
Questions