EE15N
The Art & Science of Engineering Design
Winter Quarter 2017

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JANUARY 25, 2017
Lecture
  - Defining Client’s Design Problem
Speaker
  - Ellen Levy, Silicon Valley Connect
THIS WEEK’S ASSIGNMENT

- 1-paragraph Problem Statement – i.e. a description of the problem that your project will solve.
- Due by email at midnight.
- The problem statement should be of appropriate scope, be specific, and should not include the solution in the problem description.
NEXT WEEK’S ASSIGNMENT

- Due Next Wednesday, February 1 at Midnight
- Report on how society shapes technology or vice versa
  - Examples: stem cell research, smart phones, the Internet, Twitter
- A case study of a complex engineering project.
  - Examples: the IPOD/iPhone, Facebook, the space shuttle, the power grid, MRIs, electric cars
- Describe in more detail an engineering project executed by one of our guest speakers
- Pick your own topic related to engineering design

Second Writing Assignment Due March 1
LECTURE

DEFINING THE CLIENT’S

Design Problem
PRODUCT DEFINITION PROCESS

- Translate and clarify client’s wants.
- Identify limits – what can’t client have.
- Prioritize client’s wants.
WANTS VERSUS GETS

WANT

Animal that can carry People and/or Goods

GET
Want to provide enough information in statement to determine if solution is a good one, or the best one

Want to ensure the statement has no errors, biases, or implied solutions.

Example: Design a bottle for a new children’s juice drink.

- Is there enough information to create a good/best design?
- Are there any biases or implied solutions?

PROBLEM DEFINITION SHOULD NOT INCLUDE THE SOLUTION
METHODS TO DEFINE PROBLEMS

- **Questioning**
  - Learn from clients/users/experts.
  - Prepare for meeting by listing questions and by organizing thoughts.
    - What questions would you ask of the juice company about their new bottle design?

- **Brainstorming**
  - Early brainstorming session might be useful to gain a list of objectives or constraints.
  - Information may be useful when talking to clients.
The Danbury Elementary School of the Claremont Unified School District has a number of students with the diagnosis of cerebral palsy (CP), a neuro-developmental impairment that causes disturbances of voluntary motor function. For these students, activities that require fine muscle movements (e.g. writing) are particularly difficult because of impaired motor control and coordination as a result of CP. There is ample evidence indicating that these students write more effectively when an instructor physically stabilizes either the hand or the elbow to reduce extraneous movement. A device that can achieve the same physical effect by counteracting the involuntary movement would be desirable since this would increase the students’ functional independence.
 QUESTIONS REGARDING PROJECT STATEMENT

- What does the client - *Danbury Elementary School* - want?
- What does the user - *Jessica the 3rd grader* - need?
- What does it mean to *write more effectively*?
- What does it mean to *increase students’ functional independence*?
Write revised project statement early:

- Remove errors.
- Identify and address biases.
- Make implied solutions explicit, or eliminate them.
The problem presented to the team involves Jessica, a third-grader at Danbury Elementary School. Jessica has recently begun painting, but because she suffers from cerebral palsy, she has difficulty pursuing her new interest. Jessica painting with her left hand, with her elbow held above the rest position, using a combination of arm and torso movement. While painting, Jessica exhibits exaggerated movements, and lack of control of finer movements, in all direction. These problems are amplified when her arm is fully extended. Currently, when Jessica wants to paint, she requires a teacher or staff member to hold her left elbow stable.

The staff at Danbury school has asked the team to try to design a device that would decrease the magnitude of the exaggerations and assist Jessica in controlling her finer movements. The device must permit the same range of voluntary motion currently employed while painting. Thus, the device would take the place of the teacher or staff member and increase Jessica’s functional independence while painting in a classroom environment.

The Danbury staff must be able to set-up the device in a classroom environment in eight minutes or less. Optimally, the device could be used by other students with cerebral palsy or other functionally similar conditions at Danbury Elementary school.
The Danbury Elementary school of the CUSD has a student diagnosed with Cerebral Palsy (CP), a neuro-development impairment which causes disturbances of voluntary motor function. For this student, activities that require fine muscle movements, such as painting, writing, and eating, are particularly difficult because of impaired motor control and coordination. There is ample evidence indicating that this student paints more effectively when an instructor holds onto the lower portion of the upper arm (right above the elbow) and thus minimizes extraneous movements of the shoulder.

The school desires a device that can minimize the student’s involuntary shoulder movements and thus allow her to paint semi-independently. Such a device would ideally be applicable in other CP cases and must be easily implemented by an adult.
Our group is interested in applying athletic and sport design toward a humanitarian cause, specifically relating to the use of clean energy to power the impoverished world. When outdoors and especially prone to sunlight, people wear hats to protect themselves from the sun. But what if a hat could also produce electricity and provide services from that generated electricity?

On a basic level, our hat will be covered with solar cells, which will capture the sun’s energy and transfer it, via a small wire running down the back of hat, to a little powerPack attached on the hip. The base powerPack will be a device that can charge two AA batteries, but other powerPacks can have USB plug-in capability, Wi-Fi modulator, and a lamp plug-in socket. The powerPacks will be interchangeable, depending on the needs of the customer.
Our group is interested in applying athletic and sport design toward a humanitarian cause, specifically relating to the use of clean energy to power the impoverished world. To achieve this goal, it is important to note two important trends in our possible target markets (i.e. China, India, Africa, South America): there are generally high levels of ambient sunlight and the population plays a lot of soccer.

Taking this into account, in either situation there is the possibility to harness energy that can be used to generate electricity, namely through the charging of AA batteries or the use of a unique battery that can be used to power a simple service (i.e. the generation of light).
Our group's goal is to provide clean, green energy to communities without electricity or a consistent source of light. Today a lot of 2nd and 3rd world countries are without a cheap and easily accessible source of electricity. In examining how to provide for this need, we could take two approaches: (1) introduce a new product or service and hope that it succeeds in front of a new audience or (2) innovate on an existing technology or service, reducing the need for product education.
OBJECTIVE TREE: WHAT IS IT?

- After identifying the problems or concerns and their causes, we can start to develop possible objectives for our project or design.
  - Positive statements about what the situation would look like if the problems were overcome.
  - This will help us to consider opportunities, constraints and possible strategies.
- The objective tree is a visual representation of objectives of the project.
  - MAIN OBJECTIVE is the change that you want to bring about with your solution, and the reasoning behind it.
  - Other objectives are the small goals that you need to reach in order to achieve the main objective
  - Objective tree orders main and lesser objectives in a tree structure
BUILDING OBJECTIVE TREE
WHEN & HOW?

- No hard and fast answer.
- Objectives Tree building according to EE15N:
  - Do it early.
  - Rework it often.
Device that assists students w/ CP perform classroom activities

**User Friendly**
- Safe
- Reliable

**Primary Device Functions**
- Minimize Cost
- Normalize Movements
- Max range of voluntary motion

**Features**
- Portable
- Adjustable
- Convenience
- Ease of Set-up
- Maximize Comfort
Design should minimize involuntary movement of the upper arm
  - Should be safe
  - Should be comfortable
  - Should be durable
  - Should not impair/restrict voluntary motion

Design should be applicable to multiple individuals and wheelchairs
  - Size should be adjustable
  - Mounting mechanisms should be adaptable

Design should minimize the cost of production

Restraint mechanism should be easy to install and maintain
OBJECTIVE TREE OF PROJECT CHARGECYCLE

[Diagram of ChargeCycle™ objectives and criteria]
SETTING PRIORITIES

- Some objectives are more important than other.
- How are we going to recognize and measure it?

Pairwise Comparison Charts
PAIRWISE COMPARISON CHARTS

- Individual rank orderings
  - Rank goals that are at the same level in the hierarchy of objectives.

- Aggregate rank orderings
  - PCC voting by members of a design team must be used carefully.

- Ranking scores are a useful guide for further thought and discussion.
MEASURING ACHIEVEMENT

PRODUCT DEFINITION PROCESS

Translate and clarify client’s wants
Identify limits – what can’t client have?
Order client’s wants

OBJECTIVES TREE

How do we know if the product once designed will meet these objectives?

Need metrics to measure success
DEVELOPING METRICS

- Identify units and scales for the thing to be measured.
- Identify means of assessing values of a design in terms of units and scales selected.
- Evaluate whether or not particular measurements is feasible and appropriate.
CHARACTERISTICS OF GOOD METRICS

- Actually measures the objective.
- Correct level of accuracy and tolerance.
- Repeatable.
- Understandable units of measure.
- Unambiguous interpretation.
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Metrics</th>
<th>Conclusion</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize number of sharp edges</td>
<td>Number of sharp edges</td>
<td>Inherent sharp metal edges</td>
<td>Fail</td>
</tr>
<tr>
<td>Minimize pinching</td>
<td>Number of pinching possibilities</td>
<td>User quite comfortable</td>
<td>Pass</td>
</tr>
<tr>
<td>Finger Friendly</td>
<td>Number of places on device to get finger caught</td>
<td>Not safe to handle</td>
<td>Fail</td>
</tr>
<tr>
<td>Durable</td>
<td>Disconfiguration, misalignment of device after regular use</td>
<td>Insecure mount, misaligns</td>
<td>Fail</td>
</tr>
<tr>
<td>Remain secure on user</td>
<td>Conditions under which device remains securely attached to user</td>
<td>Arm remains attached to device</td>
<td>Pass</td>
</tr>
<tr>
<td>Maintain stable position</td>
<td>Conditions where position, orientation of device maintain mounting setting</td>
<td>Insecure mount</td>
<td>Fail</td>
</tr>
<tr>
<td>Minimize cost</td>
<td>Estimate dollar amount</td>
<td>Less than other products</td>
<td>Pass</td>
</tr>
<tr>
<td>Normalize arm movement</td>
<td>User ability to draw straight line compared to ability to do so without device</td>
<td>Failure in extensibility hurts use</td>
<td>Fail</td>
</tr>
<tr>
<td>Maximize range of voluntary motion</td>
<td>Degree of freedom in motion of wrist, elbow, arm, and torso</td>
<td>Comfortable range of motion, except torso forward bend</td>
<td>Pass (except torso)</td>
</tr>
<tr>
<td>Movable while in use</td>
<td>Required assembly condition to move device</td>
<td>Does not require disassembly</td>
<td>Pass</td>
</tr>
<tr>
<td>Transportable</td>
<td>Necessary level of disassembly for movement</td>
<td>Does not require disassembly</td>
<td>Pass</td>
</tr>
<tr>
<td>Usable by multiple students</td>
<td>Range of permissible arm sizes</td>
<td>Adjustable size permits various arm sizes</td>
<td>Pass</td>
</tr>
<tr>
<td>Objectives</td>
<td>Metrics</td>
<td></td>
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<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Safety</td>
<td>Measured by number of possible ways in which device can cause bodily harm. Scale: Total Point = 10 - # ways to cause harm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stabilization</td>
<td>Ability to resist sudden accelerations. Scale: 1 to 10 by Subjective Evaluation</td>
<td></td>
<td></td>
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<tr>
<td>Comfortable</td>
<td>Perceived comfort of device. Scale: Total Point = 10 - # sources of discomfort</td>
<td></td>
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<tr>
<td>Non-Restrictive</td>
<td>Measured by the area of allowed motion. Scale: Total Point = 10 (Area/2 square feet)</td>
<td></td>
<td></td>
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<tr>
<td>Ease of Installation</td>
<td>Measured by the number of minutes required for installation. Scale: Total Point = 10 - 2(Minutes Required)</td>
<td></td>
<td></td>
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<tr>
<td>Durable</td>
<td>Measured by flimsiness, points of failure, ability to resist torques. Scale: Total Point = 10 - # points of failure</td>
<td></td>
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<tr>
<td>Adjustability</td>
<td>Measured by the device’s ability to fit a range of wheelchairs and individuals. Scale: 1 to 10 by Subjective Evaluation</td>
<td></td>
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<tr>
<td>Low Cost</td>
<td>Determined by the production cost of one unit. Scale: Total Point = 10 – (Cost/$200)</td>
<td></td>
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YOUR TURN

Develop an Objective Tree and associated set of metrics for a self-driving car
TODAY’S SPEAKER

ELLEN LEVY

Silicon Valley Connect