Capstone Invent

- Motivation
- Capstone Ideas
- Short Walk to the Edge of Knowledge
- Evolution vs Big Leaps
- Context powers Innovation
- Diverse network – be a node!
- Mass production
- Tools build tools (and jigs) to invent
- The best designers…

Why are you here?

- What motivated you to become a chemical/environmental/biological/civil/ mechanical engineer?
- How important is passion or a connection with meaning in your choice of a career?
- What will motivate you to get up and go to work every weekday morning?
- What kind of capstone design project do you want to do?

Previous Capstone Ideas

- Historically the ideas from Capstone design projects have moved into the AguaClara Design Engine or became research projects
  - Flow controller – dose controller
  - Vertical flow flocculator design
  - Economic analysis of flocculator channel width
  - Arsenic removal
  - Small (1 L/s) and large (1000 L/s) plants
  - Chlorinators
  - Enclosed StaRS Filters
  - New inlet system for StaRS Filters

3 New initiatives

- Create a plan to provide safe water to small communities in
  - Puerto Rico (a general island wide diagnosis)
  - Bolivia – several towns on an island
  - Colombia – rural town
- Aide_Design
- Non-linear CDC for simplified chemical dosing for small flows. Variable dosing valve to replace slider on CDC to simplify small systems.

AIDE Design Modules

- Entrance Tank
  - PVC design for flows from 1-5 L/s
  - civil works design for flows from 6-60 L/s
- Flocculator
  - 10-100 L/s (vertical flow in channels)
  - 1-5 L/s (pipe flocculators): cost comparison of H=D (baffles separated by distance S) and S=D (baffles separated by distance H) designs
- Sedimentation tank (civil work)
  - channel design from flocculator to filters (flows from 6-60 L/s)
  - remainder of sedimentation tank (6 m long floc blanket zone)
- Sedimentation tank (PVC pipe) for about 1 L/s
- OStaRS (open stacked rapid sand filter) (8 to about 25 L/s per filter)
  - Entrance/Exit tanks including flow control weir
  - Filter box with manifolds, slotted pipes, and winged pipes
- EStaRS (enclosed stacked rapid sand filter) PVC pipe
  - 12 inch diameter filter
  - 24 inch diameter filter
  - 36 inch diameter filter

AIDE_Design

- Identify all of the constraints that you will use for the design.
- Identify a methodical step-by-step path to design the unit.
- Create algorithms to turn the constraints into design specifications (dimensions).

The opportunities for learning new things are incredible

- It is a very short walk to the edge of knowledge
- There is always potential for evolution in theory, design, and practice
  - Evolution doesn't necessarily take you to the best solution!

Major improvements to water treatment technologies are still possible!

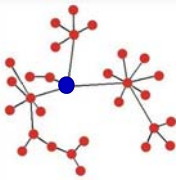
- Innovation can be a big break from evolution (or from state-of-the-art)
  - Dose controller
  - Stacked rapid sand filters
- Dramatic changes in design targets (W_{Sed}, V_{Sedup}, V_c, G_{Floc}, depth of floc blanket)
- Try extreme conditions and learn what fails or perhaps find unexpected success!

Invention are born in a context

- I never perfected an invention that I did not think about in terms of the service it might give others...I find out what the world needs, then I proceed to invent it. -Thomas Edison
- Learn the history and current state of the technology
- Then question it all and proceed to Invent

Innovators Build Bridges between Networks

- Make connections with completely different networks
  - Get outside your social class, your country, your business, your university
  - Get diverse experiences, take things apart, experiment, fail, **observe...**
- **Flocculate Ideas!**
- **Be a node!**



Capstone **Invention**

- I am not asking you to design something that 100s of engineers have designed previously
- I am asking you to invent something new, something better than what currently exists

What kind of an Engineer are you?

- Good at using Google? Did you need Cornell for this?
- Satisfied with making one design at a time?
- Able to think about the context and create new solutions and new algorithms?
- Able to generalize the problem and the solution
- Intrigued by the possibility of creating new systems (and jigs)?

Are you Ready for the Transition to Mass Production?

- Historically Environmental Engineers have resisted standardization
- Each water treatment plant was custom designed
- Perhaps we saw this as job security
- We liked to think that each problem we were solving was unique

100 years before AguaClara…

- Early on, manufacturers did not standardize car models - each car was a custom production
- Multiple early car manufacturers began standardizing and mass producing identical cars
- Ford incorporated the Ford Motor Company in 1903, proclaiming, "I will build a car for the great multitude."

AguaClara Introduces Mass Production of Designs

- Ford in 1903, "I will build a car for the great multitude."
- AguaClara in 2005…
  We will design a water treatment plant for Ojojona
- AguaClara in 2006…
  We will build a jig that can design customized water treatment plants for the great multitude
- AguaClara in 2017… time for a new jig!

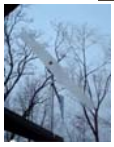
Jigs: Can you connect this to AguaClara?

- A **jig** is any of a large class of tools that help to control the location or motion (or both) of a tool.
- The primary purpose for a jig is for repeatability and exact duplication of a part for reproduction.
- In the advent of automation and CNC machines, jigs are digitally programmed and stored in memory.
- The jig is often much more complicated than the piece being built!

http://en.wikipedia.org/wiki/Jig_%28tool%29

Jigs…

- Provide control and repeatability for production work
- I've been making jigs since the late 1970s
- Wooden stars, tops, and windmill blades



Jigs: Provide control and repeatability for production work

- Taking the concept of a jig to the next level
- ProCoDA – a jig that can be easily configured to automate many different kinds of experiments
- aide_design – a jig that can easily be configured to produce designs of anything!

Evolution of how engineers created drawings

- Room full of draftsmen
- Computer drawing 2-D then 3-D
- Parametric drawing (given H, W, L, T it can draw a tank)
- Engineered Parametric Drawing (given flow rate it can draw a municipal water treatment plant)
- Aide_design!

How do you Invent?

- Question EVERYTHING including the Question Why not make deep flocculators more efficient?
- Ask WHY? Why baffles?
- Sketch new ideas – create a ranking
- Remember what you know Mass is conserved
- Watch out for your assumptions

Breaking flocs is bad (maybe)

What is Intelligent Design?

- Identify the **O**bjectives
- Identifying the correct **C**onstraints (sketch them) and create dimensionless parameters
- Creating the best **A**lgorithms based on Physics, Constructability, Maintenance, Economics
- Converting constraints into **D**imensions using algorithms
- Convert Dimensions into **Layouts**

Beauty?

- Do aesthetics matter?

La 34 | Cuatro Comunidades | San Matias



- Beauty in equations, algorithms, facilities, and in a healthy community

Innovation

- Ask what if we…
- Requires a willingness to make mistakes
- Play with geometry to generate new insights
- Try to unearth and revisit each design assumption
- Remember physics and social context: know your constraints

Frugal and Generous

If we are going to make the world a better place we will need to be frugal and generous

Frugal: careful about spending money or using things when you do not need to : using money or supplies in a very careful way

Generous: freely giving or sharing money and other valuable things

: providing more than the amount that is needed or normal : abundant or ample

: showing kindness and concern for others

The best designers…

- Explore how changes in design constraints affect the geometry (rotate, invert, make it square, make it round…)
- Create multiple graphs or sketches showing relationships
  - Text is NOT how you invent new ideas!
- Don't assume a constraint is set in stone
  - Exploring options quickly – fail fast!

Creativity with geometry

- Play with geometry (stacked filters)
- As scales change the optimal geometry can change radically (flocculators that switch from vertical to horizontal to pipes)
- Ask what happens if we
  - Turn this 90 degrees
  - Rotate this so it lines up with the plate settlers
  - Try a different layout
- Select the simple solutions

Use tools

- Use the aide_design code as needed. No need to recreate the code.
- Investigate what others have done to solve similar problems

Writing in Jupyter

- Craft a report that can be read from top to bottom
- Include sketches, equations, comparisons
- Spell check
- Make sure someone from your team proofreads the entire document before submission
- Explain your solution steps from objectives to constraints to algorithms to dimensions to layout