FROM NULL SET TO NUCLEAR POWER PLANT: THE ULTRAVIOLET DIARIES

GE SAFEWATER® CASE STUDY

PREPARED BY:

JULIA CHRISTMAN
JACQUES CHIRAZI
JIANG CHUAN WANG
SCOTT GALIC
MIKE GIANCOLA
MATT HILL

PRODUCT DESIGN AND DEVELOPMENT
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I. SUMMARY OF EVENTS

Week 2
10/7/03: The birth of the Tuberators

Week 3
10/13/03: First group weekly meeting: Production of "Preliminary Needs Assessment" and a Mission Statement. Determination of three subgroups to further efficiently delegate tasks. The groups: Ease of Assembly, Aesthetics and Added Functionality. The three individual groups each met individually to produce aspects of the upcoming progress report.
10/17/03: Interview site determined: After correspondence with IRPS alumni, the El Nino community was confirmed as a destination for the first round of surveys to determine actual customer needs.

Week 4
10/20/03: Weekly meeting: Each individual member produced a decomposition analysis, 10 potential interview questions and original concept generation ideas. An amalgamation of the ideas from the three sub-groups provided the beginnings of our progress report.
10/22/03: Progress Report production (final touches): Mission Statement, Interview Protocol, Customer needs, Needs Metric Matrix, Concept Generation etc.

Week 5
10/26/03: First Mexico Survey Trip: El Nino: 16 surveys conducted to gather initial customer needs from a low-income area in Mexico.
10/28/03: Major "Fire" meeting: In-depth analysis of progress report. We worked on our first assessment of concept generation ideas **in detail**. Decision to form three groups for further work: 1) patent searching and benchmarking 2) customer needs and surveys 3) product design and engineering. Production of innovation frontiers and metric discussion at the end of the meeting.

Week 6
11/2/03: Second Mexico Survey Trip: La Villa: 10 surveys conducted to gather customer needs from a different lower-income area in Mexico.
11/3/03: Weekly meeting: the focus was on developing a new needs assessment based on 2 interview trips and forecasting prototype development based on new and improved design (vertical system – "water cooler"). Contacting lead users of vertical systems.
11/4/03: Emergency Meeting: Irradiance and absorption specifications defined along with other metric specifications for vertical system, initial design draft produced, spreadsheet produced, revised needs and competitive benchmarking analysis produced, beginning analysis of customer surveys produced.
11/5/03: In class: Presentation of vertical system apparatus with drawings included. Specifics include (batch system, modular system, etc.)
11/8/03: Group Meeting regarding Design Review and Prototyping, Discussion with External Engineer about Prototype, (apparatus size, bulb positioning, welding concerns, KW hour discussion, focus on UV module only). Catapult experiment and aqua baby case work.

Week 7
11/9/03: One group member had an in-depth conversation with one of the project participants from the Berkeley team regarding spatial issues and prototype design. With the vertical design issues such as positioning the internal components have continued to plague the team. To name a

few: bulb positioning, plastic substitute for the metal exterior, batch system versus flow, and splashing still remain problems we must deal with in an iterative fashion.
11/12/03: Building process (and brainstorming) of the prototype commences. We have gathered a multitude of various components (a plastic "Sterilite" bin, various brass nipples, couplings and washers, a stainless steel tub, the light fixture and a wood piece for mounting). Despite accumulating these parts, ideal positioning is still a highly contested topic.
11/15/03: All day meeting: The first round of prototype construction begins. A functional prototype is constructed in the morning in a local tooling shop (i.e. a family garage) and the device is then later tested and discussed with the Berkley expert (Alicia Cohn) in an afternoon marathon meeting. Leaking, positioning of components, size of parts, time for sufficient irradiance and safety are discussed for the prototype.

Week 8
11/16/03: Half-day meeting: The prototype is complete, after a few silicone seals, functional (by the deadline!).
11/17/03: Prototype presentation commences. The only issues remaining left to resolve are safety due to exposure to the light, degradation of plastics, bulb breakage and stability of the final unit as a safety issue. The prototype is completed.
11/19/03: Our prototype is not considered a workable prototype by the revered upper management. This marks the beginning of the second prototype construction phase and brainstorming (in expedited mode).
11/21/03: The construction of the second prototype commences and is rapidly completed. The exterior plastic casing is shed and the new streamlined aluminum top is revealed. After a few hours in the garage (tool shop) the aluminum top and steel bottom GE SAFEWATER® is officially constructed (minus a few silicone seals). The exposure to light issue is resolved (due to the completely metal unit and plastic protected looking hole). Tampering by a negligent user is deterred with the 6 metal screw/bolt components added in. And the "robustness" complaint is firmly answered with a full metal jacket. Aside from prototype construction, the contract book details are simultaneously divided up among members.

Week 9
11/24/03: We have another meeting regarding the contract book and the corresponding presentation for the next day. Due to the ongoing prototype construction, certain sections of the contract book are ailing. The group continues to exchange information rapidly to assist in simultaneous development of all the necessary fields: manufacturing, marketing niche, strategy, and economics etc.
11/26/03: The final presentation commences revealing the stealth GE SAFEWATER® for the first time to fledgling Tuberators. Some concerns were expressed about safety in a metal unit with electricity and water in one area, which were well expressed concerns. Our group benefited from concerns over NPV calculation and financing of the GE SAFEWATER® in the long term for poor consumers.

Week 10
12/01/03 – 12/05/03: Throughout this week, the group spent a good portion of our time firefighting and fine tuning the rough draft of the contract book. This was a heinous process which was (gratefully) extended by two days. An incredible amount of time was spent understanding the rudiments of UV disinfection, superior design, prototype construction as well as the actual details involved with our manufacturing and marketing strategy. One issue that we had to deal with during this process is the fact that each time our prototype changed, our prices changed and therefore our market niche correspondingly changed. .

II. SCHEDULE

A. OVERVIEW

Our project development process lasted the eight weeks we had projected. The first three weeks of the project we were a little behind schedule. Our needs assessment and concepts generation took longer than anticipated. The fact that our customers need assessment took place in Mexico led to unexpected delays in our overall needs assessment process. First, we had to develop and test the Spanish version of our survey. Second, we ran into difficulty finding the right community to target in Mexico. Third, our concept generation and selection process also turned out to take longer than expected. The team had to make radical decisions on the actual design of our water disinfection system. Based our customer needs and our technological understanding, we decided to move from a water flow system to a batch system. Once we had accomplished this critical milestone the following steps were easier to achieve. The last four weeks turned out to be challenging but the team was gaining momentum as we moved into the actual building and testing of our product. Finally, the unexpected wildfire in San Diego County did not cause much delay to our project partially because we took advantage of the 3-day school closure to schedule additional meetings.

B. GANTT CHART

Activities	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Mission Statement	■							
Customer Needs	■	■	■					
Concept Generation		■	■	■				
Prototyping					■			
Prototype I					■	■		
Prototype II						■	■	
Prototype testing					■	■	■	
Presentation							■	■
Contact Book							■	■
Case Study								■

C. MILESTONES AND ACHIEVEMENT PROCESS

Our team completed a number of tasks and achieved the following three key milestones:

1) Our concept generation process was driven a series of by long meetings and intense discussions, which were critical to the development of our final design. Our team had to cope with the lack of scientific knowledge about water disinfection but fortunately, we had access to scientific support especially from Alicia Cohn and other technical experts in the San Diego community. The primary breakthrough during this step was the radical decision to move away from water flow system to a batch system. This change in design characteristic was driven from our customer needs assessment and the technical expertise of our scientific experts.

2) The completion of our initial prototype design gave us the opportunity, for the first time, to visualize and test our primary assumptions. We encountered various difficulties assembling some of the parts we had originally planned to use. The team developed viable alternatives and was able to deliver a working prototype. The product was made with an outer plastic container and an inner open stainless steel dish. The light fixture was strapped on the side of the plastic container. In retrospective, this stage of product development gave us the chance to overcome unexpected hurdles and shortcomings. Even though this prototype was not ultimately satisfactory, it provided us with a solid foundation to build on.

3) The development of our second prototype design was strongly encouraged by upper management due to the unsatisfactory structural and safety shortcomings of our first prototype. The team decided to reconsidered alternatives to address some of these structural and safety issues. The "re-design" process gave us an opportunity to experience with new ideas and new material. We decided to completely enclose the light fixture in an aluminum container to address some of the safety and structural concerns. This design proved sturdier and easier to assemble than the previous prototype.

D. MAN-HOURS

The distribution of work among team members was evenly distributed. Throughout the process, we usually divided into smaller groups of two to three to improve efficiency and productivity and these groups would meet separately during the week to complete their given tasks. Also in the earlier stages of the product development process, we assigned individual tasks to spark creativeness and innovation. Towards the end of quarter, the frequency and duration of the meetings definitely increased in order to complete all of the required tasks. Even though these sessions were long, it helped resolve complicate issues and provided opportunity for each member to express their opinions.

III. MINI-CASE STUDIES

A. CONCEPT GENERATION AND SELECTION MINI-CASE STUDY

i. WHAT WE DID

Our concept generation process differed from that for a completely new product in that initiated concept generation based on the Berkeley UV Tube product parameters. From our initial customer needs assessment we determined that the product had to meet the following four basic needs: (taking for granted that we would be able to completely disinfect the water):

- Be able to (relatively) quickly disinfect enough water to meet the daily needs of an average sized family
- Be affordable
- Be aesthetically acceptable in a household
- Be easy to assemble

We then decided that we would split into three groups to focus on different core product aspects, namely:

- Ease-of-assembly (based on the assumption that users would assemble themselves)
- Aesthetics (based on Berkeley feedback and initial customer feedback)
- Added functionality (filters, etc.)

Looking back on this process, it is interesting to see that we eventually dropped the whole idea of someone assembling this product themselves, and decided not to pursue added functionality in the prototype process because we needed to focus on the core disinfection process (and stay within time constraints). Before we split into groups we reminded ourselves that each concept would have to incorporate user safety as an overriding guideline. When we broke up we all also assumed that we would be using some basic Berkeley product parameters such as a flow model and a tubular shape. Interestingly the concept we finally chose used met neither of these criteria.

ii. CONCEPTS GENERATED

Added functionality group – This group (Mike and Jacques) focused on concepts that incorporated additional filtration functionality as a way to lower the absorption coefficient (turbidity) of the water and thus improve disinfection by lowering residence time and reducing the possibility of particulate matter shielding microorganisms from the UV light. Mike and Jacques also looked into a rainwater collection system for areas that might not have access to running water:

Figure 1: Multiple filtration concept

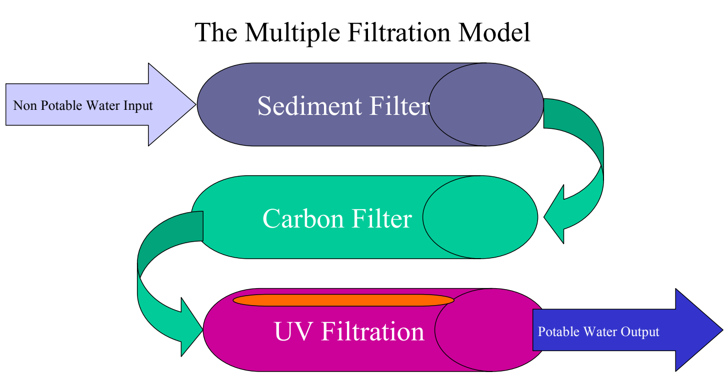
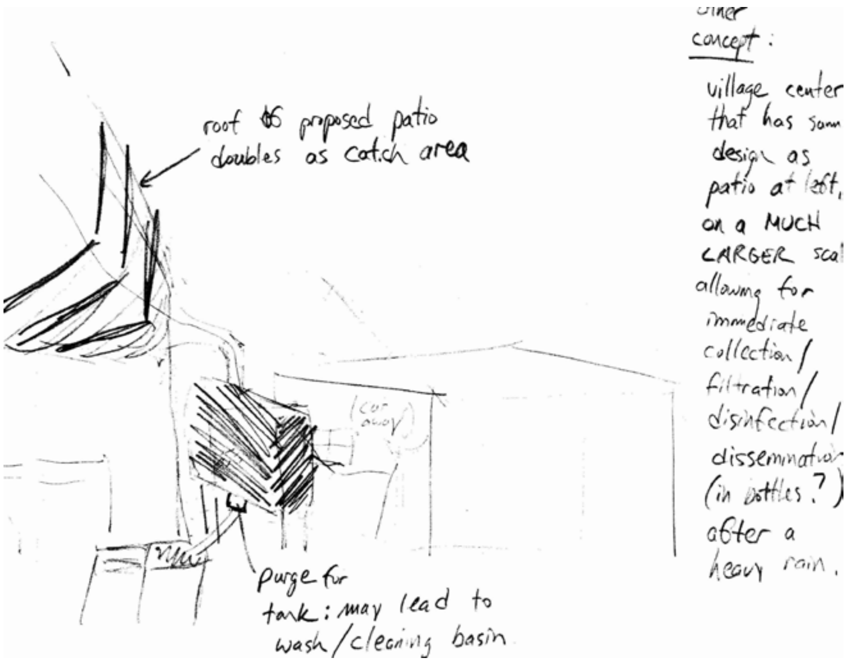


Figure 2: Rainwater collection model



Aesthetics group – The aesthetics group (Julia and Matt) looked at ways of improving the idea of a meter-long PVC tube in the kitchen, and explored making the product smaller, more convenient, and better-looking. Luckily we found out that an 18 inch bulb would work as well as a 36 inch bulb, and thus freed ourselves from the meter-long constraint:

Figure 3: Space-saving "horseshoe" model

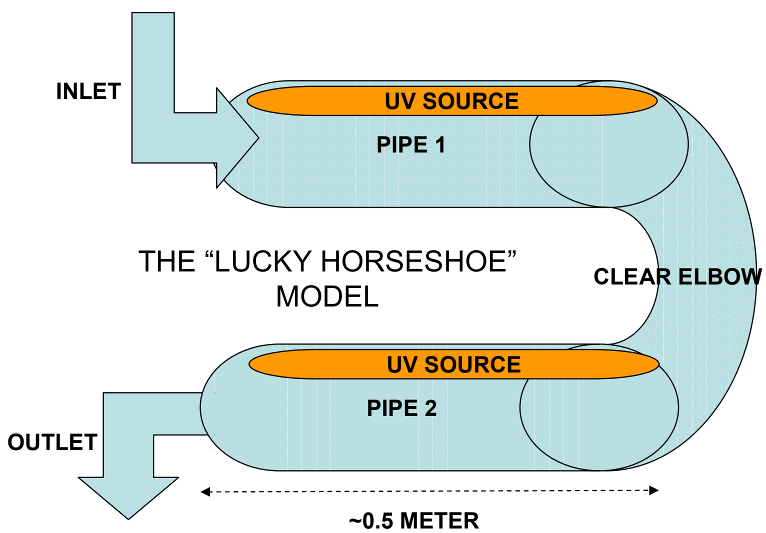
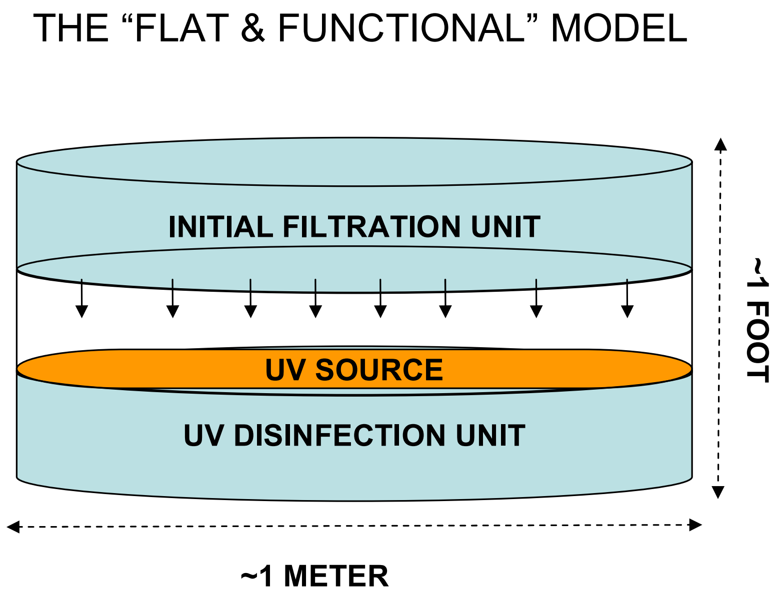
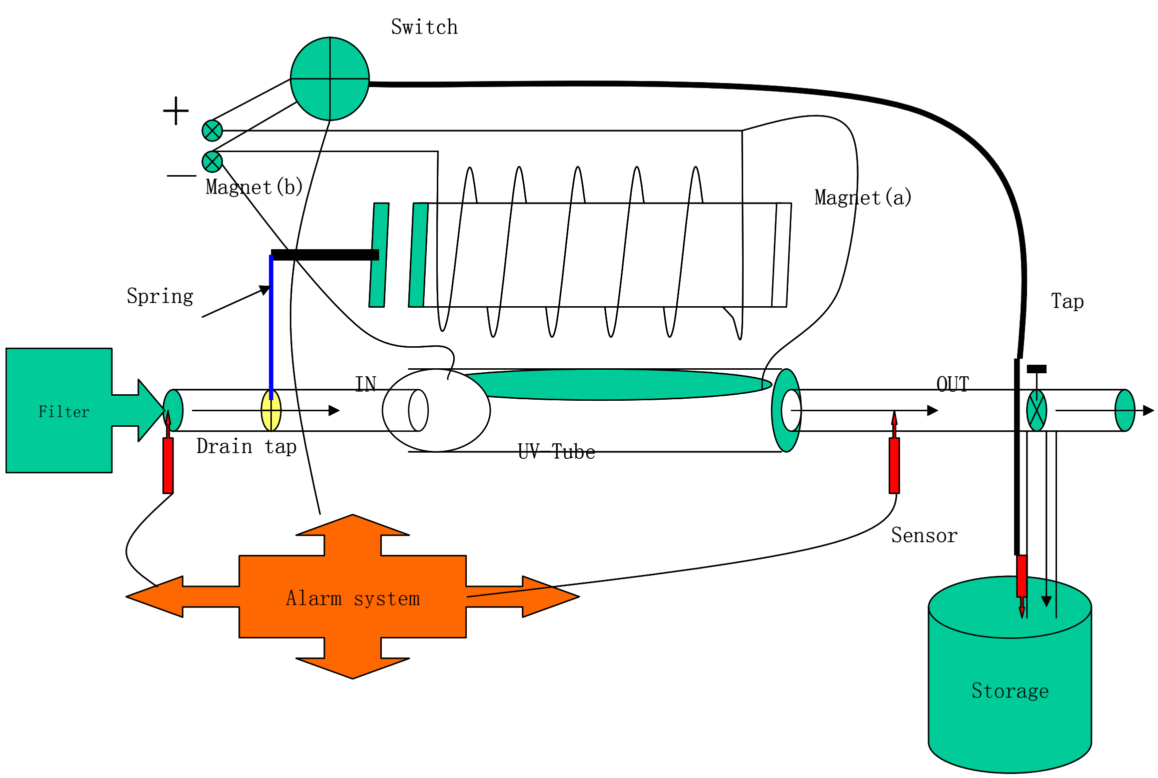


Figure 4: "Cooler" model inspired by Brita water filtration pitchers



Ease-of-assembly group – The ease of assembly group ended up focusing on user safety as their main concept goal, and came up with an innovative system for protecting the user:

Figure 5: "Safety First" model



Because we liked this concept (and Jiang) so much, we thought we would include his explanation here for exposition purposes:

“We can use a magnetic stick and wire (Magnet a) to get power that can change with the fluctuation of the electricity, then use this power to control the open and close of the drain tap through magnet b and a spring. The basic concept is that if there is no power, the drain tap is closed; if there is power, it is open, and more power more opening. Because there is a spring here, its power of flexibility will affect with the power brought by the magnet, so the flux of the water can be controlled. But how to get standard pressure of inflow water also needs more discussion, I think the filter can do this. It is only a very simple concept description here, the final one should be much more complicated than this one, but it is not too hard to design and test the function.

If the user wants the UV-tube continue work when he is out, he can do it. A sensor will turn the power off when the water is full in the storage and the surface touches the sensor, accordingly, the inflow will also stop because of the magnet. This device is very simply to realize.

Alarm system through sensors indicates that the standard of input or output is out of range, or the power is off etc. It can be connected to the inflow point, out flow point and power off switch point or more other points. Its purpose is only to make the UV-tube more safe and reliable.”

iii. FIRST ROUND SELECTIONS

After discussing the relative merits of all of these concepts we decided to choose four and then subject them to the more rigorous concept selection process as defined in the textbook. The concepts selected were the:

- "Safety Shutoff" model
- Added filtration model
- "Cooler Model” (a.k.a. “Flat and Functional” a.k.a. Brita model)
- “Lucky Horseshoe”

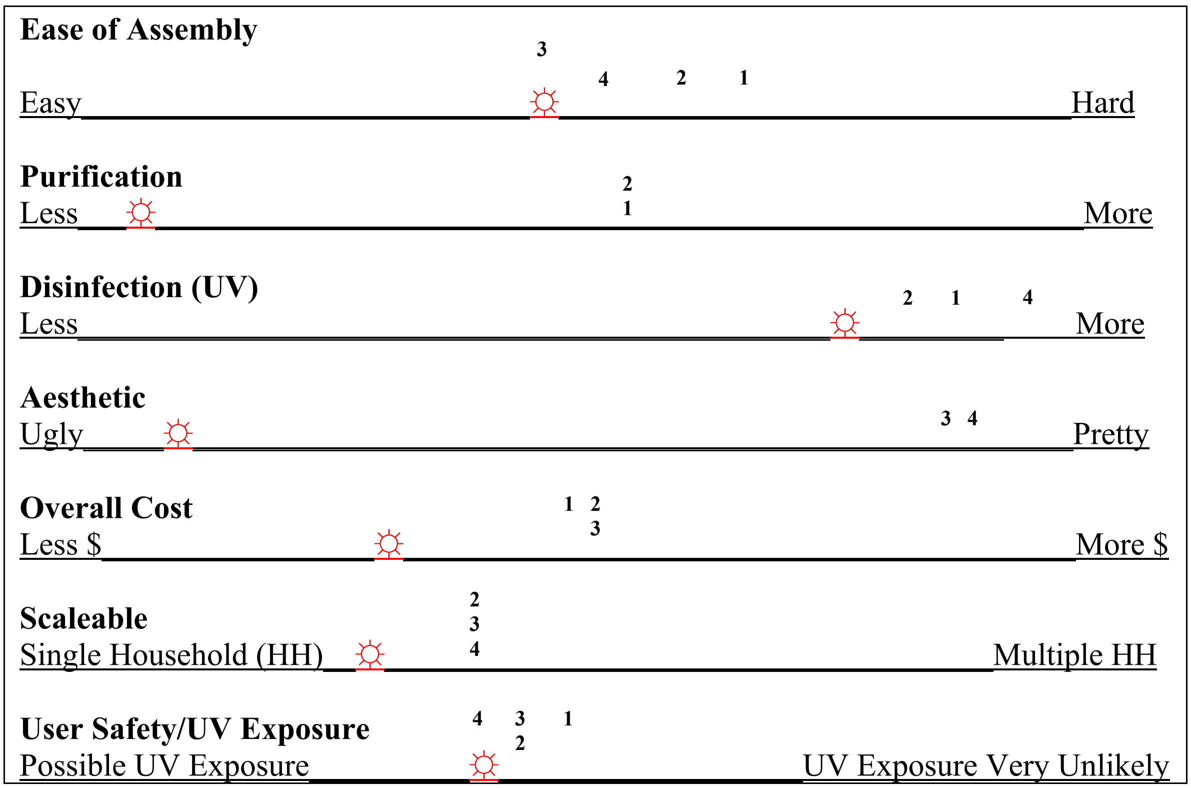
We decided to first benchmark these new concepts against the one we wanted to improve upon, the Berkeley UV Tube. By doing so we hoped to evaluate the new concepts against one that had been proven to work, at least in theory.

We numbered the concepts and scored them along seven “innovation frontiers” that we chose according to customer needs. The 4 concepts and benchmark were placed on the axes using this notation:

1. "Safety Solenoid" model
2. Added filtration model
3. "Cooler" Design (“Flat and Functional”)
4. Horseshoe Design

☼. Berkeley UV Tube Design

Figure 6: Concept selection using “innovation frontiers”



iv. FINAL ROUND SELECTION PROCESS

Based on this process we nominated two concepts that we felt were innovative and that fit our requirements. We took the “Cooler Model” and “Lucky Horseshoe” and subjected them to a final deathmatch. Since we felt the concepts were even on our innovation frontiers we compared them to the UV Tube along new parameters:

- Information requirements: How much information required by the user for assembly and use
- Cost: The lower cost the better. Includes cost to manufacture and cost to consumer (at this point we were blissfully ignorant of the realities of product costing)
- Safety: Determined by frequent exposure to UV light. The less exposure, the better.
- POU: Ability to be used as a point-of-use, household system. Does it fit into a normal kitchen?
- Aesthetics: How does the device look in the household?

- Ease of Use: Easier to assemble for user, repair, maintain, etc.

While there was some overlap with the first set of innovation frontiers, we wanted to further granularly compare these two new concepts with the UV Tube. This is what we came up with:

- "-" meaning worse than UV Tube design
- "0" meaning basically same as UV Tube
- "+" meaning better than the UV Tube

Table 1: Basic concept scoring

Design Nominations	**Information requirements**	**Cost**	**Safety**	**POU**	**Aesthetics**	**Ease of Use**
Cooler	+	-	+	+	+	+
Horseshoe	-	- -	-	+	+	0

Based on this close race, we decided on the cooler model that was inspired in part by the Brita gravity filtration products.

v. LESSONS LEARNED

STRENGTHS

We felt that it was important to try to follow the textbooks dry but detailed instructions in this process. Since we would make a final decision on a major direction for our project, we put in extra time and consideration to make sure we had looked into enough avenues. In choosing the cooler model we moved away from a user-constructed model and into a model that we would theoretically manufacture ourselves. While it was a big departure, we felt that we could better control the quality and safety considerations if it were manufactured. This provides the user with a product that they would feel more comfortable with, rather than a homemade system. We felt really good about the batch concept in that we could control how much water went in, and that the water would be disinfected and ready for use throughout the day.

WEAKNESSES

In terms of weaknesses, we went through this process between our two bouts of customer needs interviews, and thus did not have all of the information at hand. Turning this weakness into a positive, we took a couple of sketches of what the selected concept might look like and used them to elicit more helpful feedback from the customer needs surveys. The cooler concept was also the most technically difficult of the concepts to turn from sketch to concrete reality, as the next mini case study will detail.

WHAT COULD HAVE BEEN DONE DIFFERENTLY?

Customer needs information was vital to the selection of the concept. While this sounds very logical, when we were discussing the different concepts we would try to weight actual customer needs data (i.e. daily water use) more heavily than factors *we* thought were necessary to the project.

While we didn't yet know that our low-cost objective was to be shattered (which we think probably happens pretty often in PD), we felt that this concept would satisfy most all of the customer needs we had found. We didn't think that it would be easy to prototype, but that didn't enter into our selection criteria for going to the next step. This was an important psychological barrier, as we knew we would have to accurately represent the concept and that, unlike the UV Tube, it couldn't be built out of parts easily found at Home Depot. The lesson was that you can't be afraid to enter totally new territory as long as you have customer needs information to back it up.

B. PROTOTYPE BUILD-OUT MINI-CASE STUDY (VERSION I)

i. WHAT WE DID

The Design Review (DR) process was a pivotal experience for our team. Prior to the process, we had passively addressed the key safety and user-interface issues, yet we had not thoroughly dissected and analyzed the potential problems with the design. However, resulting from the DR we held an eight-hour meeting on Saturday, November 8th to tackle the following issues and incorporate them into the "next-generation" prototype design:

- *Smaller Water Container Box*. The need for a smaller size box was due to effort to minimize overall material costs and decision not to incorporate the sediment and carbon filters. We determined that we would have to build a "bare bones model."
- *Use One 18" UV Bulb.* We wanted to use a 12" bulb to minimize size; however after some research we determined that this was not a viable option. In both the US and Mexico, the 18" bulb is standard and least expensive.
- *Use Batch System.* We were weighing the costs and benefits associated with a flow system vs. batch system and decided that we are going to use a batch system for better water control (amount of radiation). In short, we chose the batch system to maximize safety and reliability while maintaining a low-cost.
- *Implement "Fool-Proof" Safety Controls.*
  a. To prevent overflow, we decided to cut holes below the UV bulb, with flapped-shields to enable the water to flow out before hitting the UV bulb. The flapped shields were added to prevent light from entering.
  b. To secure the UV bulb, we decided to mount the entire UV light fixture (21" x 2") to a corresponding piece of wood 3 cm above the water level.
  c. To ensure proper dosage, we decided to use a visual timer preset to the desired amount of time and place it outside of the GE SAFEWATER® box.
  d. To assure the user that the water is safe to drink, water testing strips will be sold with each unit.
  e. To prevent bulb shortage due to water contact, electrical tape was placed on the sides to protect the electrodes.
  f. To ensure safety in the household, four bolts were placed on the top of the plastic box so children/other household members cannot open box.
  g. To ensure safety in the household for primary and secondary users, verbal instructions/pictorials were placed on the outside of the box.

Hence, with these design issues in mind, our team delegated members find the following materials in various hardware stores, second-hand equipment shops and general building material stores around San Diego: Stainless Steel "dish," plastic grate, synthetic wood, germicidal bulb, ballast and circuitry housing, plexiglass, washers/screws, spigot (and coupling, bolts, washer), purge system with parts, PVC tube, water dispenser (from Pub) and visual timer. With these materials "in-hand," our team met the following Saturday to build the "next-generation" prototype with the generous assistance of Alicia Cohn, a graduate student at U.C. Berkeley, who is currently working on UV water disinfection systems in Mexico.

ii. PROCESSES

After a brief discussion of our day's work, we promptly started the actual building process at 12:00 p.m. It is important to point out that Scott had already assembled the "skeleton" of our design by cutting one hole for the spigot in the stainless steel dish, building the wood support structure and placing the pieces together in a working-order.

Our first issue was where we were going to place the water inlet tube in order to minimize splashing on the UV bulb. We tested different shapes, orientations of the PVC tub and determined that the 1/2" tube with no elbow design minimized the splashing better than other designs.

TESTING THE "SPLASHING EFFECT"

The next issue we addressed was the ease-of-use, namely how were we going to ensure that the user received adequate water flow. We tested two water flow systems:

- Octagonal Spigot. This particular spigot had an octagonal coupling. To fit the octagonal coupling, we cut a hole in the stainless steel box. We tested this design with water inflow and the flow of water was very slow and it leaked. We had to make another trip to ACE hardware.
- Upgraded Spigot. This "improved" spigot enabled adequate water flow. Improved water after we disassembled the flow rate monitor.

TESTING DIFFERENT SPIGOTS

The third issue we addressed was spigot leakage. To prevent spigot leaking, two systems were designed and tested:

- One washer was placed on the outside of the stainless steel box. This did not work, water leaked considerably.
- Two washers were placed on opposing sides of the stainless steel container, one hand made, one-machined.

During the first trial, we did not encounter leaking, however in a disastrous attempt to make the washer more aesthetically pleasing (to footprint the coupling) it was destroyed and a new washer had to be made. In the second trial, a handmade washer was constructed, yet this did not prevent the leaking. Our final attempt to stop leakage with another hand-made washer was successful. However, we had also applied silicone glue on the outer washer to "double-proof" the system against further leakage, so we didn't know if the actual washer or the glue, or combination of, were attributing to the leak blockage.

After eight hours of prototype building and testing, we hit a road-block. We still had to drill a hole for the outflow system in the stainless steel dish. However, our hand-held drill was rapidly running out of power. However, we were determined to finish the building process. Thankfully Mike broke out his Swiss Army knife and started filing away bit by bit, although this really didn't really make the hole any larger, it kept the momentum flowing.

TOO MUCH TESTING, SHORT ON TIME AND POWERLESS DRILL

Soon enough, Jiang stepped in and cleverly discovered the secret to using a low-powered drill to successfully cut the perfect size hole for the outflow system. Around 12:00 a.m., our team all gathered around for a group photo celebrating the completion of the Prototyping Experience (Version 1).

TEAM CELEBRATES PROTOTYPE COMPLETION (VERSION 1)

iii. LESSONS LEARNED

STRENGTHS

Team Dynamics and Cooperation

For the most part, our team was quite effective in terms of delegating tasks and ensuring that all team members were contributing to the prototype building process. However, similar to the real world where specific individuals harbor and exercise their own expertise, our team had an array of individuals with specific expertise which were tapped along the way. For instance, given Jiang has an expensive background in engineering, he was continuously called upon to determine the feasibility of certain electrical and materials configurations. Matt, the excel spreadsheet mastermind, diligently worked on devising a workable spreadsheet to determine flow rates, UV wattage, time needed, absorption coefficients needed to ensure that our design actually disinfected water.

Leverage Knowledge of Outside Experts

By working with various experts during our prototype building process, we were able to save time in terms of learning what will work and what will not work. Additionally, obtaining opinions of experts enabled us to source new ideas that were later incorporated into final design. Undeniably, Alicia Cohn, the graduate student from UC Berkeley, added immense value throughout during the entire process, but she was especially instrumental during her weekend visit for the actual prototype building process on November 15th. She added immense value in helping us determine flow rates, materials used, key safety features and overall user interface features. In addition, Scott's friend "Ben the Industrial Poet" helped us during the pre-Design Review meeting. He brought up issues such as new materials to consider and potential designs worth researching. Lastly, we contacted a local water purification sales representative about potential design materials, his name was Lou. We were fortunate that Lou was so candid with us. Specifically, he told us that his water units, as well as similar models, are so complex that finding such parts in a junkyard or in the back of a water store is next to impossible. However, he did tell us that constructing a water system incorporating carbon filters is quite simple--just granular activated carbon (GAC) crammed into a PVC pipe, capped top to bottom and sealed with food grade glue. He thought at GAC followed by UV would be an interesting design. Lastly he stated that "you guys should start a business!" Given Lou's encouragement, we carried on with the idea in mind to incorporate filters.

WEAKNESSES

Late-Start

Though Scott had already constructed a "skeleton" of our working prototype to work with from the beginning of our day-long prototype building experience, we had never actually tested it. Because our team was approximately one-week behind schedule in terms of building the prototype and testing it, we were strapped for time and as a result, our team did not conduct as many tests as desired. Perhaps, if we had more time, we would have solved some of the leakage and design problems in a more sophisticated manner. However, we had a deadline to hit and our testing process surely suffered.

Some Firefighting

Our team experienced various symptoms of firefighting during the prototyping phase of development including:

- Not enough time to solve all the problems. Give our time constraint, we had more problems to solve than our team members, and outside experts, could deal with properly.

- Many of our solutions were incomplete. Many of the problems we encountered, we had to deal with retro-actively (i.e. washers, different size holes in the stainless steel container) and there fore, we superficially solved the issues, however the underlying problems still existed.

Even though it is suggested that some firefighting is not necessarily "disastrous," in our case, we probably would have benefited from an earlier start to minimize this inefficient mechanism to tackle problems.

<u>WHAT COULD HAVE BEEN DONE DIFFERENTLY?</u>

As stated previously, our team would have benefited from an earlier start and limited firefighting. We definitely waited too long to actually operate and test the prototype. Additionally, we may have benefited from using and altering an existing water cooler, however we were unsuccessful in our search to find an adequate design within our budget. As a result, we fell into a firefighting mode which decreased our efficiency and compromised the level of our testing process. However, it must be pointed out that while some firefighting existing, our team acknowledged the symptoms and actively worked together to increase the efficiency and focus our team members either solving the root of the problem or avoiding it altogether.

B. PROTOTYPE BUILD-OUT MINI-CASE STUDY (VERSION II)

i. OVERVIEW

Although the design review was a critical tool used in our previous prototype construction, the time constraints of a few days put more pressure on what we were about to produce. This condensed time frame limited the amount of options we could successfully pursue. The areas that we were working to improve were:

- *More robust exterior unit*. We were constructively criticized about the robustness of the material we were using. Our plastic “Sterilite” unit had the potential to possibly degrade over time. Additionally, its Tupperware-esque nature didn’t instill confidence (in upper management) about the prototype’s long term durability.
- *Mounting improvement.* Although the unit could be considered a self-standing device, concerns were expressed over the possibility of such a unit being knocked over.
- *"Fool-Proof" Safety concerns for users*. Although, we dealt with these issues in our initial prototype, our reasoning and product wasn’t deemed sufficient. The easily removed top facilitated access to the user in an unsafe way, permitting possible exposure to the dangerous UV light. We hadn’t locked the unit to prevent tampering. Additionally, although the plastic exterior could possibly withstand UV light exposure for a period of time (Sterilite had not done testing on this), there was no guarantee that the unit could sustain this type of exposure over the long term.

Due to the expedited time frame, and desire to move on to other course components, these issues were resolved rapidly by a small quorum of the team. At this time we were operating without team member Giancola, which prompted the reaction that these decisions were going to be made by a less than desirable majority of the team.

ii. PROCESSES

In order to advance the robustness of our unit we had initiated a debate on the possible materials we could use for the housing of the disinfection unit. A verbal concept selection period took place over a two day period before construction took place. Possible options we discussed were:

***Wood**:* Initially, we thought wood would be ideal as it is a readily available resource, cheap, and easily to work with for the layperson with a modest set of tools. After consulting with a wood expert the idea was quickly diffused. Reasons why a wood box isn't a good idea (the wood man Frank Gallic speaks):

1) Wood definitely expands and contracts; it does this a lot in extreme temperatures.
2) Purge and outflow out of the box, we've yet to discuss.
3) The water proofing idea isn't feasible, a temporary fix.
4) Stainless steel protection, mounted on wood isn't easy to drill holes through.

***Plastics**:* A more durable manufactured plastic was also discussed as an option but we did not have access to a plastics lab or the financial budget to have something molded for this purpose. The previous results with degradation on ABS and PVC were also worrisome issues not wholly separate from using a more durable plastic.

***Metal**:* This was the best option that we had discovered to date. It would reflect dangerous UV rays within the unit, thereby increasing disinfection, while containing all of the rays as well. This elimination of exposure to UV rays was a big advance. Additionally, the unit was lockable in the sense that we could manipulate it to prevent negligent tampering. The only dilemma was finding this unit.

Fortunately, team member Jacques bought a used aluminum bin for $15 that fit flush to our stainless steel unit. This was a watershed moment! This left a weekend for construction of the ominous second prototype.

Only a small portion of the team (3 members) was available for the actual construction of the second prototype. While we lacked the insight of team members we benefited from the small group dynamic with respect to speedy decision-making and less storming

Within four hours we managed to finalize our concept selection, create a theoretical design review, patronize the local Home Depot and Dixiline, and rapidly construct the second prototype at the Gallic Garage. Go team.

GOOD FRIDAY EVENTS:

- Purchased 2 U bolts, sufficient washers and bolts for safety locking, an in-line switch at the Home Depot.
- Arrived at the Gallic Garage for drilling and metal mayhem. (The aluminum top was incredibly easy to drill through in comparison to the stainless steel bottom; however this didn’t prevent Matt and Scott from fumbling around with the drill - operating it in reverse mode - sheer brilliance).
- Mounted the light within the U bolts under the aluminum top
- Jacques cut the obsolete plastic bin to produce a safety window for the new and improved prototype (and broke a jigsaw blade in the process – perhaps too much power was used).
- Electrical manipulation of the light device (in-line switch rewiring, and receptacle placement).
- Prepped the device for final sealing, outflow and purge placement, and spray painting

No ashes, but plenty of metal!!!
Front View   Back View

iii. LESSONS LEARNED

STRENGTHS
Small Team
Although insight from the whole team would have likely produced beneficial digressions and a more detailed concept generation, the small team was strength in producing this prototype in a very quick fashion. Decisions were made quickly with less deliberation. This enabled us to quickly complete this phase with minimal storming and firefighting. This was a crucial stage in our PD process, as it rejuvenated the group for the other foreboding tasks that lay ahead.

Accessible Working Environment
This process wouldn't have been possible without the right tools and fortunately we had access to them. A hardware intensive product for this class is like lighting a match inviting firefighters to come along. We narrowly averted this due to the readily available resources we had on hand.

WEAKNESSES
Short time frame
We expected our initial prototype to be considered a workable prototype and therefore we were quite surprised when told that we would need to produce a new or a substantially altered prototype. With the short amount of time left in the course, we were operating under less than ideal conditions for group decision-making. This time frame led into firefighting for concept selection, design review, and component placement.

Limited Budget
We decided on the "full metal jacket" (completely metal unit) primarily because we gained access to cheap materials. This device could consist of different materials if our budget permitted the purchasing or production of such materials. "New" metal components or a prefabricated plastic mold were ideas we would have liked to pursue but steered clear of because of price issues.

WHAT COULD HAVE BEEN DONE DIFFERENTLY?
Had we anticipated the inefficiencies of our first prototype we would have had more time to deal with the second round of prototyping. The elaboration on concept selection and design review would have produced a superior product and potentially produced a design with plastic rather than metal, electricity and water.

C. CUSTOMER NEEDS MINI-CASE STUDY

i. OVERVIEW: **CONDUCTING SURVEYS IN MEXICO**
The initial goal of the UC Berkeley project was to produce a disinfection device that could be marketed to low-income families in the developing world. Our initial group assumption was to cater toward this market niche as stated in our mission statement. In order to get accurate results

from the customer, we traveled to Mexico on two separate occasions to gather the highly coveted customer needs. On both occasions we sampled a slice of the lower socio-economic spectrum:

Trip #1 – El Niño

In El Niño we passed out pre-tested surveys to twelve members of a Catholic church. Of the congregation, respondents came from El Niño, two other surrounding communities, and as far away as Tecate. Four of the surveys were given randomly in the town's central market. This survey was to determine if there was a need for a UV disinfection unit as a point of use system among many other needs. Some of the customer needs that were elicited by the visit to El Niño were:

- The unit is safe.
- The unit can be used within the home.
- The unit is cost effective.
- The unit cleans customers' water comparably to current methods.
- The unit is aesthetically pleasing.

Trip #2 - La Villa

In La Villa, we conducted a similar survey but altered for given the changes in our concept generation phase in class. Additionally, we determined visual stimuli were beneficial to detect latent needs in further detail hence we included drawings as well. By changing the community we were able to ascertain that another location had access to large scale UV disinfected water. Some of the customer needs that were elicited by the visit to La Villa were:

- The unit is easy to operate.
- The unit design is stable (does not tip over).
- The unit does not appreciably increase my electricity costs.
- The unit footprint fits easily into the kitchen workspace.
- The unit is cost effective.

ii. METHOD

The method of how we conducted the interviews varied in the two locations. Number of interviewers, interviewees, and survey population all differed in the two locations. The details are disclosed below:

Trip #1 – El Nino

The trip included five people (with one volunteer to translate). This enabled us to start the interviews off in pairs in order to have some checking mechanism for bias while also having a photographer. After feeling comfortable with the process, we attempted to obtain more data by having one interviewer per interviewee.

These interviews were conducted in front of a church and at a nearby market place. We had made this connection to the community through an IR/PS alumna, which made the environment more comfortable. All of the questions were systematically asked and answered in chronological order. One bias that may have influenced responses was the incentives we provided in the form of pens and snack food.

Trip #2 - La Villa

This trip only included two interviewers therefore we obtained fewer results. Additionally, the only connection we had to the community was a recommendation by an IRPS student who previously had business involvement in the community. Therefore, having no starting point required for the two interviewers to actively seek out interviewees in various parts of the community.

iii. LESSONS LEARNED

STRENGTHS

The primary strength of these interviews was that we conducted primary needs assessments, much better than the preliminary needs assessment where we estimated the hypothetical needs. Although the trips to Mexico were time consuming, the visual evidence and first hand accounts were invaluable.

WEAKNESSES

Unfortunately, we occasionally had native Spanish speakers conducting the interviews and for the majority of time we did not. The level of Spanish varied amongst our non-native speakers, therefore there was room for mistranslation and misinterpretation. Another weakness was that the interviewed sample of society may not be representative of our actual market niche. The mission statement was eventually changed focusing our product on a market niche consisting of middle income consumers in developing nations. The individuals we interviewed may or may not reflect this market niche.

IV. OVERALL ANALYSIS OF PROJECT

A. KEY DRIVERS: "WATERSHED MOMENTS"

The following four anecdotes represent the key drivers that caused our project to go in the creative direction that it did.

i. THE NULL SET

With week two of the quarter came the concept proposal deadlines that would lead to the formation of project groups. I (Mike Giancola) joined the class two sessions late, and by my own complete fault, arrived at class on Wednesday of week 2 completely unprepared, but with an idea in mind. When the group approached the corkboard walls of the Robinson Bldg. 1201 with their concepts, I sheepishly huddled behind my laptop searching for the words to describe a water filtration and disinfection project that I'd heard about the previous summer from a friend.

Finally Prof. Bohn forcefully announced, "DO I HAVE ALL OF THE SUBMISSIONS, BECAUSE WE NEED TO VOTE ON CONCEPTS." I said, "Um, no, I haven't turned in anything yet…"
Prof Bohn Replied: "So then I do have your assignment."
I said, "No, I just said, I haven't turned in anything yet…"
Bohn- (smiling) "Then I've got everything from you"
Me – (quizzically) "No, I mean, I don't have anything!"
Bohn-(smiling wider) "That's right, I've got everything from you, because you brought the null set to class!"
(*laughter from all at this point*)

With some encouragement from my concept generation group, I was encouraged to present my idea, and for some reason, Prof. Bohn allowed it as a nomination, despite the fact that I'd not yet written it up. This was key to the project not being killed off (to the later chagrin of my group members)!

ii. PRODUCT BENCHMARKING/CONCEPT GENERATION

About one month later, several ideas had been generated regarding installation of the product, possible scientific alterations to the UC Berkeley original project, aesthetic improvements over the tube shape/ artwork.

What was come up with was something that was, and is, in our minds outstanding. We did a benchmarking exercise comparing a possible batch product (making large batches of water for storage) instead of the current design of the flow model that UC Berkeley made up, and also comparing a few other models that we had thought up during exercises completed over the previous week.

The importance of the benchmarking session was that we realized that we could generate a concept that was significantly different from the model that we'd been studying and based on items in our needs assessment and some of our own assumptions about convenience and style could bring it along to a finished prototype. This is where the UC San Diego UV Box or 'Safe Water' product was born.

iii. MEN (AND WOMAN) AMONG ABSTRACTION

Once we knew that we needed to go in the direction of a UV Box that would hold batches of disinfected water, we needed expert help to theoretically prove some of our assumptions.

The Woman among Abstraction, a true scholar, is Alicia Cohn who was able to convey her own experiences from the field in the state of Michoacan. Mexico and relate them to our task at hand. Her presence at the time of original prototype construction truly helped us to confirm suspicions about how water works, and how it can be safely disinfected.

Man among Abstraction #1: Reed at San Diego Lighting. Costs, design specs, peripherals, Reed was our UV Germicidal Bulb God and we thank him for his entire candor. He was able to tell us both cost and measurements-wise what was and wasn't feasible in Wattage of bulb and fit in minutes, for what might have otherwise been hours of internet or library research.

Man among Abstraction #2: Lou the Water Guy. "Call Lou the Water Guy" If you look around on all of the water dispensing machines in the Robinson Admin. Building you will find this sticker on all of them. While we listened to Prof. Haggard dishing knowledge about the 1982 market for Commodore 64's outside of his fourth floor office threshold, he flashed us a puzzled look from behind his steel rims, like, 'Are you guys really going to tear that thing out of the wall?' Of course, 'that thing' was the fourth floor professors' water cooler, and our group was in a moment of need, the need to see how these things really worked, and were really put together. Enter Lou the Water Guy whose number was prominently displayed on the cooler. Lou let us know about everything from putting homemade filtration together to the actual markups on the materials…and even told us that we could be self made millionaires with enough sand and pvc.

Man among Abstraction #3: Matt Hill. It is probably not fitting to include a group member as a Man among abstraction, but then again, most people just go back to sleep after they have a PD nightmare. Sometime around week 5 of the course Matt Hill had one of those nightmares while fighting off a head cold in his bed…but instead of going back to sleep, his febrile dream caused an epiphany: The UV Box dosage modeling spreadsheet. Replete with macros on the table, Matt made everything that we were discussing in theory a reality, now all we had to do was to make it watertight and unbreakable- how hard could that be? Tougher than we thought originally, but AT LEAST we had some scientific modeling to back us up. .

iv. PLASTIC WON'T DO...ONLY CHEESE IS ROBUST

"It's just not robust enough," was Prof. Bohn's comment regarding the original prototype design that our group came up with. Having had some scientific assurance that we were in the clear safety wise with a translucent plastic bin as our containing vessel, we went ahead with a stainless steel inlaid-into plastic design.

For several reasons it was agreed upon by our group that the design had to change. First and foremost was a comment by a PD Alumnus from a former class:

> When Roger tells you that you *should* do something, it means that
> you *need* to do it.
>
> -Victor Peng (PD Class of '02)

So the gauntlet had been laid by professor Bohn and we needed to find a way out…in a week's time. This truly was watershed, because we needed to act fast and do some fundamental design change – no more "firefighting"!

Enter "The Full Eagle". The full Eagle used to fly choppers and heavier craft all over the seven seas for the US Navy but now resides in East County, San Diego. With the use of the Full Eagle's workshop, robust things could happen and did. In the words of Yoda:

There is no try. Do or do not. There is no try.
Spielberg (Empire Strikes Back, 1982)

The full Eagle realized the enormity of the task at hand and supervised the group as we worked well into the early morning hours drilling holes into metal a bit more than the neighbors would have liked.

What emerged was the GE SAFEWATER® prototype, an all metal, opaque model with plexi-protected spyglass and water purge for fool proofing. Battleship gray in honor of the Eagle himself.

B. HOW WOULD WE DO IT NEXT TIME: "20-20 HINDSIGHT"

As we look back on the quarter there are definitely several things we would have done differently. The number one difference would have been in getting physical sooner. By this we mean that we would have started building models sooner. We feel that if we would have gone more quickly from concept selection to building we could have avoided the last minute crunches and spent more quality time on the paperwork and research aspects of the project. Because we were still building when we were writing the contract book, there were some aspects of the final prototype, such as cost, that we had to incorporate into the contract book in the final stages of writing it.

Overall the group was good about making deadlines and making time for long meetings, but we could have been better at making agendas and sticking to them. We tended to go off on tangents, which were necessary, but ultimately we may have engaged in firefighting a couple of times when looking at the big picture would have saved time and hand-wringing.

Starting the spreadsheet modeling of UV dose and product costs would have also paid off, as we didn't know until very late that our product would end up costing the user well over $100. Although the economic analysis lectures came late in the process, we should have looked into the costing aspects earlier.

We had a fun time joking about how much easier a surfboard lock would have been as a project, but in reality we felt we may have learned more about the PD process by tackling a technology that is still relatively new in the consumer marketplace.

V. INDIVIDUAL POST-SCRIPTS

JULIA CHRISTMAN

Although it is difficult to reflect on a process that is still on-going, I will do my best to step "outside the box" and provide relevant insights. After completing most courses, you file away your papers and projects knowing that you will probably never look at them again. However, this class is different. After navigating my way through the project development process, I honestly feel like I have useful "take-aways" that will be directly applicable to my work in the real world. Undoubtedly, I am thankful for being part of a well-rounded, dedicated team, given all the hours spent together and heavy work-load. Definitely, a good sense of humor will go a long way under the given time-constraints and stress evident in Professor Bohn's Product Development Class.

At first, I was a bit nervous about the sheer number of team members. From my past experiences, generally a team consisting of more than four to five members is too large, especially for projects with a short time line with numerous deliverables along the way. However, our team of six worked out quite well in terms of overall cooperation and coordination. A portion of this success can be attributed to Mike's effort to put together a "UV TUBE" folder on Firstclass which enabled us to post relevant questions, comments and suggestions regarding the status of the project. When dealing with large teams, sometimes it feels like more time is simply spent informing team members of project status instead of actual work. This was a great idea on Mike's behalf.

Undeniably, we chose a difficult product to design with many different components. I feel fortunate to have such competent team members to deal with issues such as the UV bulb wattage levels, absorption coefficients, and flow rates. There were many times when I thought "what did I get myself into?" However, my team members never ceased to amaze me and pulled though at the most critical moments. Moreover, given somewhat complicated inputs, I feel like our team achieved enormous success in terms of product innovation. Our original flow-through design was quite similar to the UC Berkeley's system but was only slightly different in terms of the aesthetics. However, after going through the product development process and innovating along a variety of frontiers (user safety, scaleable, easy of assembly, and aesthetics), our final product was remarkably different from our original design UC Berkeley's design.

Similar to the Aqua Baby case study, my advice to next year's students is two-fold. The first part is to build a working prototype, regardless of how rough the design may be, and test it as early as possible. There is no doubt that many issues evolve during this process and it always takes longer than expected to deal with unforeseen issues. In order to prevent firefighting, you have to start this process early. Work with time, not against it. My second piece of advice is to have fun, maintain a good sense of humor and enjoy the process.

JACQUES CHIRAZI

After going through this product design and development course, I am convinced I made a good choice taking this course even though at first it was a little bit overwhelming. As I was going through the textbook and began to work on my team project, I realized how each section was tightly interconnected with the next. The planning and organization, and timing turned out to be critical elements to complete our project on time. Tasks outlined in the course and textbook that may seem like a waste of time, actually contributed to keep us on track and on schedule.

Personally, I feel that my team was dedicated and productive throughout the project. I think that we chose a somewhat a difficult product to design however the challenge forced us to exceed beyond our own knowledge. Even though all of us had very busy schedule, we all allocated time for this project and used our personal strengths accordingly. I believe these elements were essential to completion of our project. One element that I feel we could have improved was the length of some of meetings. Even though we had agenda for each meeting, we usually went beyond the schedule time. I think in part it due to the size of our team. I realized time management is probably the most difficult skill to master, but I feel that this project gave us an opportunity to improve this particular skill.

Throughout this project, I learned that every drawbacks or hurdles that we went through turned to be valuable lessons. Each time we learned from it and move on to the next phase of product development. For example, I think we should have built a prototype sooner, which would have helped us visually identify some of the unforeseeable problems early in the development process. In the second prototype, we decided to rectify some of the structural and safety issues by considering an alternative design. This iteration process is an essential part of the development process, which led to a better design. I believe if we had more time available, I think we could have improved even more on our final design.

As for the suggestion for the course, I think the case study should be assigned in the beginning of the course. The drawback is that in the beginning of the course, we don't have enough knowledge about product development to take advantage of the case study. Finally, I would suggest assigning a case study on economic analysis to give us the chance to practice and understand how is done before we do it for the contract book.

MATT HILL

From the start I was really excited to be a part of this project team, I looked forward to learning all about UV disinfection technology and about building a product with a potential to help people. I guess I didn't realize what we were diving into – tackling a technology that none of us knew anything about would entail some real heavy lifting, both mentally and physically.

In the beginning phases of the project there was an incredible amount of information to digest, from the basics of UV disinfection to a careful study of all of the Berkeley UV Tube documentation. In order to even start thinking about customer needs and concepts we had to internalize what UV was and what it wasn't, as well as an insane amount of small details such as the internal workings of fluorescent light sources (who knew what ballast was, anyway!).

In hindsight it seems like we took a long time to really start gathering momentum, we would spend hours and hours talking about small details and we seemed to take for granted that we would be using a flow process like the Berkeley UV Tube and that we would be using PVC. I felt like we really started to gain speed after the concept selection process, but when Jiang and I went to Home Depot we couldn't really find any materials that would let us build the "UV Cooler". However, in walking amongst the aisles we happened upon two other interesting ideas. One involved using a waterproof "flashlight" model to disinfect water inside of containers, thereby also disinfecting the container and so ensuring safe storage. The other would prove to be prophetic, we walked by the display of GE SMARTWATER products and starting thinking about how this concept, with UV added, would be a good starting point for a prototype.

We then bought a fluorescent light source and started to really dig into how they worked, and I think this was the watershed moment where we decided that it would be much easier (and probably cheaper) to assemble this thing out of pre-made parts, thus avoiding much of the assembly that was essential to the UV Tube model. From here it was a short leap to deciding on a manufacturing business model.

At this point we had still been neglecting the modeling aspect of water volume, actual product dimensions, and UV disinfection efficacy. The design review was coming up and we still hadn't put anything in a spreadsheet. I had the flu at this point, and for several hours one night I was tossing and turning as nightmares involving water flow and ultraviolet dosage ravaged my very sanity. The next morning I got up and started working on the spreadsheet, and by our meeting that night we had figured out how to model irradiance in a simple way, and by extension the dosage of a UV light source on water. We sent it out to Alicia and she actually thought we had done a passable job (for non-scientists of course). This was a huge load off of my mind, although the model would take up a considerable amount of my time for the rest of the project.

I was really disappointed that I missed the first prototype building session, but I was to have my chance at building later. When our initial working prototype was rejected I think the whole group felt disappointed at being sent back to the drawing board by "upper management". I felt that the key idea of a working prototype being something that could be given to a consumer to actually use was not communicated to use beforehand. So after being frustrated for a couple of days we decided to build the all-metal box. It was really fun building the second generation prototype, and at one point Scott's dad had to intervene because I was putting all my strength into drilling a hole in the metal while the drill was in reverse. After we had sanded and painted the top and put the thing together, I think the whole group was happy that we had decided to go the extra mile. To use one of our most overused clichés, it "instilled pride".

In terms of the course itself I thought the book was dry but helpful, especially in processes such as concept development and selection. I thought the milestones were essential and well-placed in that they really pushed us to move the process along. It was kind of strange being in a class that was divided into two camps, the Grocery Gophers and the Tuberators. I sometimes felt like we were competing, a situation analogous to separate project teams within companies. I thought it brought some good creative tension to the process.

<u>SCOTT GALLIC</u>

Reflections in Muddy "Unsafe Water"

What ever happened to the surf board lock? Wow.

In all seriousness, I feel like this group went above and beyond the call of Product Design duty with the UV disinfection "SAFEWATER" project. The amount of time expended on what appears to be useless activities (at first glance) was extraordinary. In actuality it was absolutely necessary. We explored extensive tangential ideas and processes and somehow our group remained patient and cohesive. Perhaps our team members retained some undefined traits in PD parlance, aside from your typical (engineering, statistical or financial) skills. I think this is why I enjoyed the class so much. The line between professional and idiosyncratic behavior was crossed multiple times which branded our group meetings as fun events rather than stereotypical work meetings.

We spent plenty of time in the mucky waters of storming and concept selecting gone awry. Throughout these processes I was continually asking myself privately, are we really capable of resolving these sorts of issues? Who is the capable engineer? Who is the established Economist? Who is the capable scientist well versed in such issues? With each question someone provided an answer and the project continued. As a group, we managed to overcome the obstacles that an IDEO team would confront with less money, time and resources. This is what fascinates me most.

MIKE GIANCOLA

I am unsure that the title 'Product Development' or the amicable 'PD' moniker that this course has really does it justice. Perhaps it would be more applicably named: BEWARE! Roger Bohn will be your psychologist for the next eleven weeks. All kidding aside, the course filled a certain gap in my thinking about the way products are made and/or improved. Further, it is a hands-on, experientially based workshop in the challenges of correct alignment of personnel for optimal business outcomes.

After our first couple of meetings we quickly realized that specializing everyone to the tasks that they most wanted or in some cases, were most well equipped to take on, was the only way to really do the course assignments justice. It also closely simulated what we'd learned was the real world situation of the necessity of specialization of labor for a task so demanding regarding deadlines and thoughtful concept generation.

I'll never forget the class where Professor Bohn challenged us to storm. Storming, he said, was the only way any truly creative group can make real progress. While our group certainly stormed on a couple of occasions (one in the case of presumed customer needs, pre-assessment and the other in the case of concept generation) we always kept it on a respectful and professional level. The truth is that I've never worked with such a naturally, almost accidentally cohesive group. I think that started from a core of people who all had a lot of confidence in their own abilities and was willing to joke around and also take risks, knowing that they wouldn't be ostracized greatly or necessarily discounted by other members of the group. That balance between confidence and fearlessness to bring up new topics in the group was tremendous.

The nature of the project itself demanded a group with a composition such as this. All of us except one had no experience in an engineering field, the presumed focus of the product. None of us were native speakers of Spanish, the language of the target market of our customer needs survey. Truthfully, it took us a while to get our project up to speed with the demands that the course was making on us. While the project in that way was a liability (its complicated nature) it was also its strength. A lofty goal like bringing clean water to populations that don't otherwise have any is definitely enough fuel to keep a group of idealistic kids fired up, so to that end our project focus was useful.

Thanks to Prof. Roger Bohn who clearly puts his soul into making the PD experience an experience in not only design and organizational structure but also in human nature.