Applying Design Thinking

to Reimagine Aquaponics: A Case Study

> ***"Simple can be harder than complex:** You have to work hard to get your thinking clean to make it simple. But it's worth it in the end because once you get there, you can move mountains."* -Steve Jobs

By: George B. Brooks, Jr. Ph.D.

I like to eat healthy and good flavored food. I'd wager most people would join me in this particular preference and small aquaponics systems with grow beds 3 to 4 square meters in size, like those described in the Food and Agriculture Organizations manual "Small Scale Aquaponic Food Production" are a demonstrated path toward achieving this goal (Somerville et al. 2014). This basic design inspired the creation of thousands of small aquatic farms scattered across the nation's rural and urban backyards (Brooks 2018). In the years since, some of the significant complaints that could limit expansion of these small systems to new users are the realities that they can be expensive to build or to buy, complex to operate and disposed to breaking down, thus prone to fish kills (Brooks 2019). (See Figure 1).

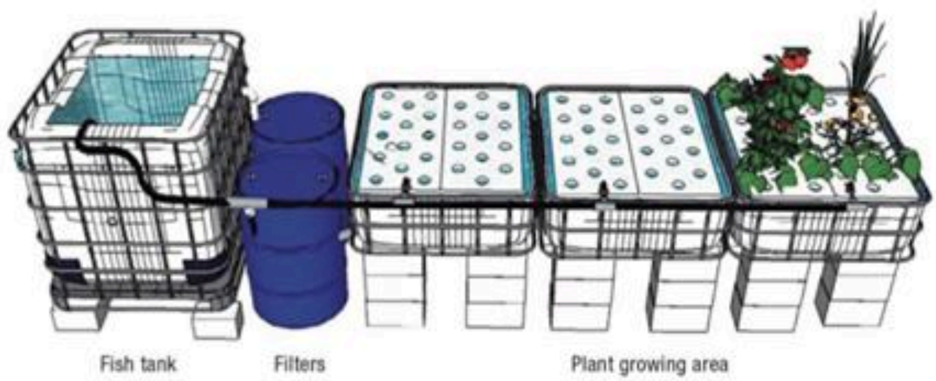

Figure 1. Basic configuration of a small Deep Water Culture (DWC) aquaponics system from the FAO manual.

One of the challenges toward creating more robust and less expensive to build and operate aquaponic systems is loyalty to that basic design that was developed sometime in the '90s, and propagated by uncounted YouTube videos and numerous books, that is "good enough" to meet users' needs. According to Wikipedia, the principle of "good enough" is when consumers will use products that are good enough for their requirements, despite the availability of more advanced technology (Wikipedia 2019). It was great for its day but even great disruptive innovations need to be reimagined now and again to keep up with the times (Brooks 2018).

One process that may address this issue is Design Thinking (DT). Design Thinking is an approach to innovation that works to integrate the potential of technology and the requirements for economic success with the people's needs (see Figure 2). According to Fortune Magazine the term "design thinking," was coined back in 2003 by IDEO company cofounder David Kelley. Today it is widely used as an user-centric approach to innovation by a wide variety of corporate entities including Apple, IBM, Fidelity, Intuit, Samsung, Airbnb and many more (Chandler et al 2018).

Some years ago I had the opportunity to address the challenge of reimagining aquaponics to meet the needs of my direct community here in Phoenix, Arizona. Looking through the lens of Design Thinking, the process I used was extremely similar to the 5-stage Design Thinking concept promoted by the Interaction Design Institute. They see design thinking as a "design methodology that provides a solution-based approach to solving problems. It's extremely useful in tackling complex issues that are ill-defined or unknown, by understanding the human needs involved, by re-framing the problem in human-centric ways, by creating many ideas in brainstorming sessions, and by adopting a hands-on approach in prototyping and testing"(Rikke and Siang 2019).

Stage 1: Empathise

To "Empathise" is to gain a clear, near view of the problem one is trying to solve. This implies taking a deep dive into the question to find out all one can. This will require talking to experts, technology users and customers to ascertain what they see as their needs. Most importantly this empathetic process allows the user to put aside his or her preconceptions to gain more accurate insights into the issues at hand.

Stage 2: Defining the Problem

Once all of the users' and customers' needs are understood, one must now define the problem in human terms. For example, for a family to eat well from an aquaponics system similar in size to the ones described in the aforementioned FAO manual, depending on the skill of the user it must be able to produce healthy, high quality produce and fish at a competitive cost.

With such a human centered problem in hand, the various design elements to address for a solution become clearer. In this case such a DYI system would need to be user friendly, low in cost and easy to build. It would also need to have a smaller space footprint, be inexpensive to operate, easy to harvest (fish and vegetables) able to produce as much (or more) high quality healthy food just as fast as (or faster than) other designs, but be less subject to breakdowns that reduce product quality and harvests amounts.

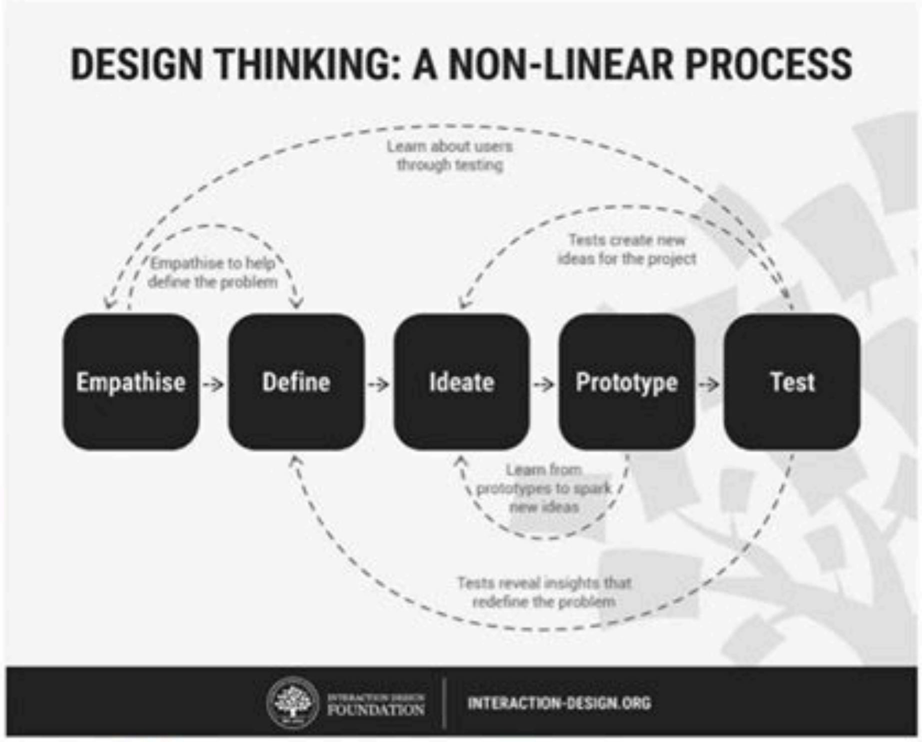

Figure 2. The 5 stage Design Thinking format from the Interaction Design Institute.

Stage 3: Ideate

To "Ideate" is to form new ideas and concepts. This is an opportunity to think beyond the box and not be limited necessarily to concepts previously used to attack the problems at hand. Within my experience, KISS (Keep

After a few trials and errors a workable concept was developed to utilize these splash pools. However, it required one to abandon the traditional layout of an aquaponics recirculation system and replace it with a design inspired by the IPRS (In Pond Race Way System).

Figure 3. Underused backyard splash pool filled with green water.

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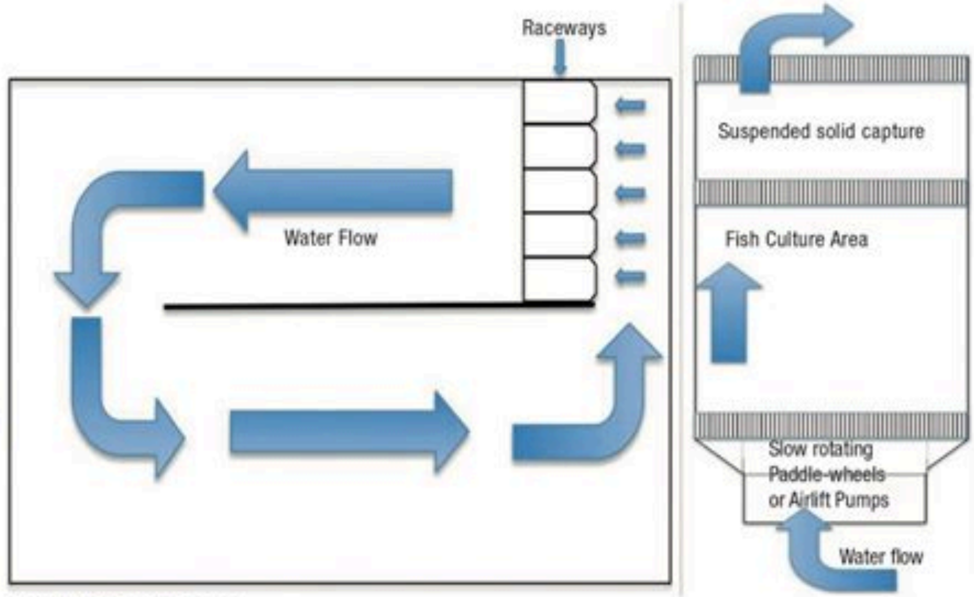

Figure 4. IPRS system diagram.

It Super Simple) always worked well when trying to solve a problem. I think Steve Jobs of Apple may have said it best in the quote shared at the beginning of the article.

Interestingly enough, the effort to move beyond the box actually led figuratively and literally back to a box. Wherever I would travel I would see pools similar to the one pictured here in a backyard near Chicago Illinois (see Figure 3), unused and filled with green water growing mosquitos. With perhaps tens of thousands of these pools, underused and apparently spread across the country, would it not be great if they could be made to grow food instead of bugs? The question would be how? (Rikke and Siang 2019).

Stage 4: Prototype

The prototype stage is when one throws the results of the ideation up on the wall, and then builds test models of the ideas that stick. The splash pool stuck. However, the first idea of how to use it did not. As stated by the Interaction Design Foundation, "this is an experimental phase, and the aim is to identify the best possible solution for each of the problems identified during the first three stages." One concept drawn from the Internet, as had been tried by others, was to simply use the pool as a fish tank and then plumb grow beds, clarifiers and bio filters to the outside as would be done with a traditional IBC system. Though the size of the tank did protect the fish somewhat from power failures, the system took up a lot of space and was no less complex to build or costly to operate than traditional designs. In addition, plumbing PVC lines through a layer of Vinyl pool liner and an internal fish safe/food safe liner was difficult and established a new point for potential catastrophic failure. Finally, it was difficult to get the solids out of these big tanks without actually going in and vacuuming.

After a few trials and errors a workable concept was developed to utilize these splash pools. However, it required one to abandon the traditional layout of an aquaponics recirculation system and replace it with a design inspired by the IPRS (In Pond Race Way System) (see Figure 4.)

Figure 5. Aquaponics converted circular splash pool.

There is increasing talk today in the United States of the growing "Seafood trade deficit." In other words "the U.S. eats a lot more fish than it produces in fisheries or aquaculture." One clear solution to this challenge is to domestically grow more fish.

Figure 6. Testing of splash pool configurations continues.

IPRS is a method to dramatically increase the carrying capacity of an aquaculture pond by sequestering the majority of the fish in raceways that are installed within the pond body. A zero head concept, water from the pond is moved through each raceway through the use of a paddle wheel or airlift pump. Before the water leaves the raceway it passes through a quiescent zone where solids (fish feces) drop out for collection. The water is then emptied into the rest of the pond where bacteria, algae and other microorganisms serve to clean the water before recirculating back to the fish. So in effect, the entire pond, which could be more than 10 acres in size, becomes a complete, integrated recirculating aquaculture system (Brown et al., 2011), (see Figure 4).

Looking at an IPRS configured pond from above, it required only a minor intuitive leap to see that a similar configuration of system elements, if placed into the splash pool in question with some modifications for size, plants and the use of off-the-shelf materials, could hypothetically make a simple but complete aquaponics system as well. The open biofiltration space would serve as the location for Deep Water Culture rafts. The Biological Surface Area (BSA) created by the plant roots would serve as the biofiltration media, with the vascular plants polishing the water of nitrate (see Figure 5).

Stage 5: Test

Did the idea work? Yes, and on the surface very well. However, almost nothing works right the first time. So rigorous testing of each prototype is not only a good idea, it is a requirement. Accordingly, testing of the splash pools continues with a focus on scalability and different configurations (see Figure 6). In agriculture it takes many years to even begin to experience part of the wide variety of challenges each growing season may bring. An open mind is necessary, for the results of each season will require revision of the prototype to fix what went wrong, or even abandonment of what one thought the problems that needed to be solved actually were. Just like the scientific method, DT is an unending iterative process.

This article focused on small-scale aquaponics. However, there is increasing talk today in the United States of the growing "Seafood trade deficit." In other words "the U.S. eats a lot more fish than it produces in fisheries or aquaculture." One clear solution to this challenge is to domestically grow more fish. For aquaponics to be a part of this solution, technology improvements will be necessary (Brooks, 2018). Design Thinking though, is not limited by scale. By applying concepts like DT, new and better applications may be created for both small and commercial farms to help meet the world's increasing food needs.

Editor's note: references are available directly from the Author.

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