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Aquaponics: Redefining Education for Our Youth

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Redefining Education for Our Youth

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Abstract: A Whole New World in the One We Thought We Knew

In America, we are seeing a lack of effectiveness with our K-12 schools. This costs the school districts and taxpayers money with very little return guaranteeing an ongoing investment into adulthood. Students finishing high school have very little if any applied learning and technical skills, and still need to accomplish at least four years of college or a trade school to be able to compete, even for a job not requiring a degree. Of those high school graduates, half and growing do not feel that they are prepared for college. Students also have little understanding of, or experience with, the ecology or economics of the world they are inheriting. Consequently, this impairs the ability of young adults to take the reins of, understand, predict and troubleshoot global economics, politics and the ecological externality costs of their actions. This paper acknowledges that using traditional organic gardens in schools is a time-honored tradition and is beneficial for schools, teachers, and students while still having many externality benefits. However, it finds that if funding K-12 curriculum is shifted to support the development of aquaponic farms as a foundation for standardized education, the opportunity for a more thorough education is increased. Despite high up-front costs, aquaponic farms are a good investment because of their ability to utilize applied and reflective learning in many subjects in a calculated way. Aquaponics is also upgradeable and scalable to fit technological and environmental evolution ensuring that high school graduates have hands-on experience with real and up-to-date life skills.

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Acknowledgments

I would like to thank my dad who in his life shared his love and experiences with me, how to not only be a good person, but how to never sacrifice principle; and in his death, gave me a catalyst needed to take the stage in which his teachings became tools and life became not just a point of being, but a point of mind, a point of growth. I would also like to thank my mom and step dad who has always gone above and beyond to support my journeys and have been pillars of reason in my life in which I could orbit my thoughts. Moreover, then there are all of my friends, advisors, and teachers who in their contrasting ways have given me the opportunity always to search the abyss of why's, how's and can's.

Letter to the Reader

Dear reader,

This paper that you are about to read is nine years in the making. Oh, it hurts to say that! How the years have slipped by. First, it sprouted from a study of economics, an idea to introduce a new form of currency and monetary system. However, my advisors were unsure about how to advise such a paper; it did not quite fit the guidelines of a political science degree, so I followed economics down to its core and found agriculture and something political, the Farm Bill. After reading the Farm Bill, I saw a need for reform and couldn't find any real research looking into sustainable farming practices. As I got into writing a thesis on sustainable agriculture I: a) found that I opened a can of worms and was slightly overwhelmed by shear dependence we have on agriculture as a society which made this lowly little undergraduate thesis a monster that I felt ill-equipped to face; b) it was lonely challenging the status quo and c) the day I was turning in my rough draft found that two fellows had just published a paper for their Ph.D. nearly identical to mine in content, and conclusion, except theirs had a range and detail that made my attempts look like a book report of their research. That being said, I felt it was only respectable to let my paper evolve to focus on food waste, but after turning it in found that it was not political science enough and then I ran out of money. Despite the fact that I had participated in commencement and had gone through the steps of graduation, I still had to finish this thesis to graduate, and I

found myself working on a farm to try and make ends meet. As time went on and I was more exposed to agriculture, I started recognizing all of the agricultural waste all around me. I knew things had to change… but where to start? Forcing existing farms to change via abrupt policy changes did not seem principled… however the vast majority of the world's population has been force fed misleading ideas from governments who are influenced by special interest groups who trying to become Pinocchio cutting strings of democracy influencing us to vote our ties away while on the other side of the coin we are guilted to reinvest in technologies of yesteryear by people bucking the system and going back to the earth. The government's idea of efficient farming is essentially a chemically managed hydroponic farming where the earth is the growing medium. This process causes the soil, air, water and all other systems of the natural cycle to act as sponges that absorb and receive the brutal excesses of unnatural manipulation. On the other side, we have people going back to the earth who tell us that building farms of ye olde tymes will fix the world and reverse what the Government has propagated with the fallouts and externality costs of the Farm bill. While the farming practices subsidized by the government strip the earth and pollute it, and the traditional farms work more in sync with nature, they are both farming, both intrude into nature and expand our demand for land.

Part of what makes us human is our need to grow and expand, we reach out and seek the horizon, and we are at a point where the only horizons are up and within. So, before we ricochet off the wall of the west and let the two extreme promoters of agriculture start eating their tail, our tail, we need to redirect that movement up so we can continue to work on within. However, what does that mean, "up" and how do we move that way? Over the years, I had followed hydroponics because my dad had been involved in it. He was one of the founding members of the Hydroponic Society of America, so I could not get away from it. He died when I was 11 and as life kept

going hydroponics moved away from me and re-entered my thoughts during this project. What I found was that hydroponics has grown up and is super capable but is very dependent on human interaction and solely dependent on manually putting nutrients in water for plants. I also became more aware of aquaculture, trying to grow fish in farms consisting of many large pools used for propagating and raising fish rather than catching them in the wild. Both systems were flawed in ways, but some folks found that if both hydroponics and aquaculture worked together, then they canceled out each other's deficiencies and just became better… kind of like what Love is supposed to be. This was awesome!

The more I researched, the more I saw potential. But the costs. The market. It is a risky endeavor, and any trailblazing modern farmers need to charge a premium to survive while also competing with the government's subsidized foods to a growing number of consumers who are falling from the shrinking middle class. So many people also have this stigma of what is farming and what is right… SO how do we influence momentum for this mysterious "up" direction against the tides of the status quo? Kids… what about kids…our future generations, what about schools? I started looking at schools and found a surge of organizations wanting to build gardens in schools… However, something was not right… they were building gardens that were sending kids back to the stone age, figuratively speaking… then I found my inspiration, I found my in, and I found money… and with some help from some lovely folks here at Dominican, I was able to drop the confines of my political science major and create my own interdisciplinary major, Sustainable Culture and Politics, through the Humanities and write the paper the way it needs to be written rather than fit into the narrow confines of a discipline-specific major.

So why do I say all this, why does this timeline matter? I'm thirty-three years old, I've been an athlete, a soldier, and a student among many other titles. I have been responsible for the

lives of this nation's children as they go off to war; I have driven over a million miles around, across and through this country, and have pushed my body and mind to places that I could never have imagined. But yet this paper is the hardest thing that I have ever done… so many times I have wanted to throw in the towel but I could not…I could not throw in the towel because from all the research that I have done in the years leading up to this, I could see us heading right into a loop, repeating the past, except on the next pass there would not be the resources and flourishing earth to absorb our mistakes, and there seems to be very little standing in the way of that loop. Friends, family, and teachers have told me to keep this paper simple and just get it done… but that is not what I do… so I met everyone in the middle. What follows is a paper that pulls from many directions to try and show the density as well as the breadth of the of the topic, all while sticking to the point and being brief.

Thank you.

Joshua Peal

Introduction- Education vs. the World

"Problems cannot be solved with the same mindset that created them."

-Albert Einstein

Before we can begin to critique education, we must address the state of the world because preparation to face that metric is exactly what education should be working to develop. To do this, we must ask what our idealistic goal for education is? What does it take to have a successful society? We must ask if our model of education is creating an environment for children to learn not just about how to function in a world where technology grows at an exponential rate and the natural environment is changing at an unprecedented rate, but are we teaching them how to command their world? Do they understand the ecology, the biology that keeps them alive? Does the current educational structure promote and encourage the mindset needed to enter the world as leaders of any scale? Are these leaders who seek creativity, are as open to learning and have the confidence to keep taking steps into the new world is sound? Are we teaching them enough to troubleshoot and communicate supporting their ability to more efficiently handle crises that have evolved politically, economically, ecologically? For many students, the answers fall short of the truth.

As of this moment, there are about 7 billion people on the planet. Within the next 40 years, it is predicted that the population will grow another 30% putting the estimated global population at around 9.4 billion people. Accounting for the global growing middle class "the world will need 70 to 100% more food by 2050," (Gomiero et al., 2011). Water, the building block of life, the miracle molecule that covers roughly 70% of the entire globe and makes life on

earth as we know it possible is, in fact, becoming a scarcity. Despite the abundance of water on this planet, only about 2% is fresh water suitable for human consumption. Of the fresh water, 75% is locked up in the polar ice caps and the air. What does all of this mean? All terrestrial plants and animals on earth must share .5% of the world's water. While life on this planet has managed to survive under this set of criteria for millions of years, humanity and its growing population has turned fresh water into a scarcity. In the United States, 40% of the fresh water has been classified as unsuitable for human consumption and recreation because modern agricultural and industrial practices have contaminated the water with hazardous microorganisms, fertilizers, and pesticides (Pimentel et al., 2004). Globally, modern agricultural practices use anywhere between 70% (Gomiero et al., 2012) and 85% (Pfister, 2011) of the available fresh water supply.

For an American who has not stepped outside of their city, state, country or economic circle it may be hard to conceive the imminent dependency that we as a society have on farming and understand the ties that our actions have on the weather and environment that cradles our farming systems. The extent of food and many raw materials that end at the general store or a favorite fast food chain is vast, and there is little understanding of the foods journey and potential journeys or the externality costs of the food we hold in our hands. Of the current population of 7 billion people, the United Nations Food and Agriculture Organization and Environment Program have found that when looking at the global population's caloric, protein, essential vitamin, and mineral intake 3.7 billion of those people are malnourished. This number is generated from impoverished countries in the global south. Surprisingly, it is true of the global north as well. "In countries of food plenty, such as the United States and those in Europe, a larger and larger fraction of poor people suffer from malnutrition due to food shortage. A survey of the U.S. Department of Agriculture states that in 2008, 49 million people went without access to

sufficient food in the United States, and more than one in five children went without enough food during the same year," (Gomiero, 2011). Taking these numbers into consideration, "the world will need 70 to 100% more food by 2050," (Gomiero, 2011) also meaning double the in the form of meat. With a growing middle class globally, however, and the desire for meat growing in proportion with the growth of the middle class, the estimated percentage of growth needed in agriculture previously mentioned would accommodate only half of the population currently facing hunger and malnutrition and pick up only a third of the additional estimated population growth.

While current farming methods do produce an excess of food, nutritional values of food are depleting. To meet caloric needs and grow sweeter foods, farmers have bred out the nutrient dense qualities in the heirloom predecessors of modern foods (Robinson, 2013).

Problem Definition- Prepare for the Worst, Plan for the Best

Acknowledging the realities or water, of nutrition, air, and soil is important but what is equally important is how to address those conditions. The hurdles that we face as a society are ongoing, and with each generation those hurdles are raised. During this time our youth face odds that are on many fronts. High school does not prep enough; college is too necessary, college costs too much, jobs are not available for college graduates, so the jobs going to college graduates are jobs that should be for those without a college education because a low skilled job provider would rather have a high skilled worker. Resources for providing funding are being spread thin meanwhile the practices within the foreign world of agriculture that stitch society together is being unraveled by itself, our lack of education and how that translates to how we

treat the environment which translates to further undermining balances on which agriculture depends. We are not educated in ways that benefit the democratic nature of our country, particularly in regards to food and energy policy and its global implications. We are not funded enough because of a lack of jobs and wealth distribution to fund this mess.

Young adults today are facing a series unique situations to which the education system is slow to respond. In 2014 UC Berkley Professor Robert Reich wrote a piece for the Huffington Post in which he stated that college degrees no longer guarantee a good job because education is so readily available. As globalization and the internet become more developed millions of people in developing nations have access to information and are getting educated. Do to the nature of capitalists and business owners to seek the most affordable labor available many companies are taking advantage of current trade laws moving their businesses to countries that require the least amount of financial input. This growth in brain power with the finesse of globalization and the internet has made it lucrative for many companies to outsource production and technical jobs overseas, meanwhile software is being written that "is taking over many tasks that had been done by well-educated professionals — including data analysis, accounting, legal and engineering work, even some medical diagnoses, " (Reich, 2014). This migration of labor means that in the United States 46% of recent college graduates and nearly 33% of overall college graduates are working in jobs that do not require college degrees. Thus jobs that do not require college degrees are hiring college graduates over non-college graduates. Meanwhile on average those with a college degree in 2013 earned 98% more than a person without a degree yet starting wages for college grads are on average 7.4% lower than they were in 2000 while only the top 10% of college grads have seen their pay go up 4.4% since the year 2000, (Reich,2014). In this data, it can be seen that students and families spend money on college to compete for jobs that do not

require college and do not pay enough to compensate for the costs of college. Simultaneously those with a college education are being favored over those that may have a superior skill set without the college degree for jobs that do not require higher education.

Despite college virtually being a necessity and while 87% of students surveyed plan on going to college, only 45% feel that they are ready and prepared with a clear career path (Leal, 2015). Coincidentally, 46% of the students feel that the career counselors from the schools helped them identify professions to pursue based on their interests and abilities (Leal, 2015). Though with a lack of applied education in schools and a lack of vocational experience with a larger focus on teaching for the tests, how can a student or counselor gauge strong interests and abilities? Conversely, the National Assessment of Educational Progress has found that only 37% of students are in fact prepared for college-level reading and writing, and that number has been steadily shrinking every year, (Camera, 2016). There is a growing body of research that is showing that having a gap of a year or more between high school and college is beneficial for the college career and the job search after college. A lot of this is because students leaving high school have no life experience or opportunity to apply what they have learned to gauge their strengths and interests. This lack of readiness shows that students are subjected to a form of education that is an act of isolation, not teaching perspective of the world giving a real-time gauge against which to challenge their knowledge.

An educational system that only provides a limited platform for learning gives us the freedom to generalize and simplify our environment when in truth that world is complex. (Ash, Clayton, 2009). “When reflection on experience is weak, students’ “learning” may be “haphazard, accidental, and superficial.” “When it is well designed, reflection promotes significant learning, including problem-solving skills, higher order reasoning, integrative

thinking, goal clarification, openness to new ideas, ability to adopt new perspectives, and systemic thinking," (Ash/Clayton, 2009).

Humans live in a globalized world and commerce is that thread that joins us together making it synonymous to compare life to business, i.e. what prepares us for life, prepares us for the world and prepares us for participating in economics so that we have the tools to be efficient and successful. For an individual or business to be successful in this capitalistic environment, they must have an innovative mindset by improving something that already exists or seeing something from a different perspective and generating new ideas (Schumpeter, 1942). Moreover, when there is a growing disconnect between children and their food and natural resources (US, 2011), it produces a citizen who does not have the basic knowledge to support democracy from the most elemental foundation of that society.

High-Level Solution- The Money Pit

In response to large disparities in education between race and economic sectors, President Bush pushed forward the No Child Left Behind bill which appeared to be an effort to create a unified educational system that would ensure that all American youths were getting an education that would allow them to keep in stride with competing nations. While at face value this program appeared to be a guaranteed success, the conditions of the program made testing across the board mandatory with the results of testing determining whether or not the school received federal funding. However, the schools with the need of funding were in neighborhoods that suffered from a cyclical cause and effect of poor education and poor employment. Lack of funding forced

schools across the board to cut out many of the arts and extracurricular activities and forced teachers to teach to the test and not educate in the broader sense of applying principles to identify, create and solve problems. As the years went forward, students kept doing worse, and the response was to give students more schooling, more homework, fewer arts, sports and free time. However, from the sidelines, many were doing studies showing how free time to express creativity, healthy school lunches, and access to applied learning significantly increases the effectiveness of education.

As these studies continued to identify an ever growing correlation between health, applied learning and creativity, all leading to a stronger understanding of effective teaching, the Obama administration made a change to the NCLB bill giving states more freedom to teach in ways that they saw fit. While schools and teachers alike are appreciative of this new freedom, they face increasingly diverse schools, and as the middle class in America continues to shrink they are also finding that tax revenue in given cities is lower and more spread out in social support programs creating less for the schools to have at their disposal. In light of these deficiencies, the question became, how can we teach such a diverse array of students with less money while providing better education? With this question in mind, educators started looking outside of their immediate circle. In looking at successful teaching practices from around the world and looking at research that had up until now been on the sidelines or thought to be outdated. Educators knew that they had to identify and maybe even create programs that would offer outlets for creativity, and applied learning that would also help promote a healthy lifestyle.

In response to trying to address a growing disconnect that many of this nations' youth have with the world, nature, their food and their creative application of knowledge while also

recognizing the state of schools struggling to address these issues with limited funding and support in the households, educators started looking at bringing back the school garden.

Of nearly half of California public schools surveyed, some of the most prominent reasons for school gardening from educators included edible produce (39%), extracurricular activities (60%) and academic instruction (89%) in order to help teach subjects such as nutrition (66%), environmental studies (70%), and science (95%), (Graham, 2005) (Stewart, 2014). Many teachers have tried building gardens but the cost to each teacher creating a small garden and the time required to maintain each garden is considerable and does not offer the depth of experience that having a full garden would offer. The small gardens also do not contribute to providing food to the cafeterias as a larger garden would. In actual practice, a majority of school gardens are slightly to not effective at providing food for the cafeterias, but educators had noticed significant benefits to enhancing science comprehension and performance, (Graham, 2005) (Stewart, 2014).

Despite the interest of educators and positive correlations to academic performance, the school garden faces many roadblocks. To run a garden requires time and knowledge, let alone funding and space. With ever increasing requirements for what a teacher must teach, many teachers are too busy not knowledgeable enough and by the end of the day, burnt out, (Graham, 2005) (Hazzard, 2011) (Stewart). As some communities began recognizing the benefits of the school garden, coalitions of educators, parents and local volunteers started collaborating to boost awareness, funding via grants, sponsorship and fundraisers, and donation streams for garden programs (Hazzard) (Stewart). To remove the burden from the teachers and to help have a garden that was maintained and managed, the most successful school gardens have hired garden coordinators that would manage the garden and help teach (Hazzard) (Stewart). The garden coordinator role also worked as a protection of investment because in many cases teachers or

parent volunteers who had spearheaded these gardens would move, retire, or follow their child to support them at the next level of schooling leaving gardens to go fallow (O'Callaghan, 2005) (Stewart).

The results spoke for themselves, test groups in Texas showed that students in the 5th grade scored on average between 5.6 and 14.9 points higher than students in control groups (Klemmer, 2005) (Stewart). When looking at the rates of improvements for subjects, sciences saw a 93%, math 80% and language arts had a rate of 72% (Williams, 2013) (Stewart) These results led educators and people in the community to start nonprofits such as Urban Sprouts, EnrichLA and much more. If an educator and wants to start a garden in their school, the should look for nonprofits in their area that are already established and have established resource streams. There are even nonprofits who work on building models of policy and curriculum such as The Edible Schoolyard Project, EcoLiteracy.org and Future Farmers of America who have designed a K-12 curriculum to assist politicians on education boards, the public, educators and garden coordinators have a unified vision and direction moving forward.

Solution Details- The Good Just Keeps Getting Better

"Problems cannot be solved with the same mindset that created them."

-Albert Einstein

To solve a problem, we must first ask the right question and then make our way towards the answer. The journey towards the horizon is where we learn, apply and test ourselves. Looking at education not as a planned path to a destination but instead as a general direction

which has a path individual for each student, allows us to let schools evolve. The benefits of adding gardens to schools have had positive results but the gardens are merely amendments to the existing educational structure and gardens cannot be used universally. Because of the changing weather and diverse climates teaching schedules, production schedules and consequently reliability is unpredictable. By investing in aquaponic farms in schools, we start asking the right question diverting the discussion from what will we teach to what is our direction and how can we teach each student to learn how to learn?

Much of modern society lives in food deserts where growing food in traditional gardens is not economical, efficient and/or feasible, whether their environment is a cityscape or a desert, there are not places or resources to have traditional gardens that can produce enough and are dependable. Traditional farming methods failed at feeding the world when the earth was still rich, alive and diverse, which is why the green revolution in the 1940s was so revolutionary. Even the most efficient variations of organic farming, multi-farming and crop rotation yields on average 9% less than a traditional farm while producing comparable amounts of legumes (Yang, 2014). While modern large scale farming is highly capable of producing large amounts of food and raw materials, the methods have high externality costs. Some of these costs have removed forests, salinized farmlands, killed top soil, wasted water, caused run off carrying excess nutrients have caused toxic algae blooms, pushed useage of herbacides and pesticieds to dangerous levels making pests and weeds that are resistant to poisons and have made the costs of farming too expensive for the small farmer. In efforts to reclaim a connection with the earth and the food, many have come back to this pre-green revolution method of farming to develop and have built a niche movement. It is part of this movement which has been brought into schools. So, despite this garden model showing a positive correlation in the education of our youth, what

we are introducing into our schools to prepare our children for tomorrow is a 10,000-year-old practice which has been proven to be obsolete and not universally applicable.

Ecology is essentially the study of how the whole natural world works together to function... from the smallest bacteria to the oceans, ourselves and everything in between. The idea of the modern small farm revolution that has initiated much of the various forms of school gardens has strong ties in the emotional/spiritual connection with ecology and not the real needs of the community at large. In most every publication promoting these school garden initiatives, the message on the importance of teaching with these gardens has weighted ideas on the importance of teaching ecology. However aside from this emotional connection with ecology, farming regardless of the intent is still intrusive on the environment. Pests, weeds, predators, continue to be identified as such in any system which is serious about maintaining a predictable market of resources which negates an atmosphere that claims market its services by teaching ecology. Ecology can, just as effectively, be taught with aquaponics while observing complete ecological cycles in the world and by mimicking isolated ecological processes in controlled environments.

In many places around the world such as Israel and parts of Africa, which are void of natural resources necessary for making traditional farming methods viable, methods commonly taught in schools, the primary method for growing plants for consumption, have shifted to various forms of hydroponic farming, more specifically, Aquaponics. However, what exactly is Aquaponics?

Hydroponics is a method of farming consists of growing plants in an inert medium such as clay pellets or lava rock. The medium is part of a closed water system with nutrients added to the water as they are needed to provide a constant supply of nutrients and water. Another

delivery system for this nutrient dense water solution is Aeroponics which mists roots instead of submerging roots. Both of these methods allow farmers to grow food in stacks and create modular growing beds that can be expanded with minimal effort. With the creation of LED lighting that provides a low heat and low energy light source that produces the spectrum of light needed for photosynthesis, farmers can grow 7-9 times more food per square foot than traditional farms. These features allow for more freedom in designing gardens that do not necessarily need to use natural light. Some other allures to hydroponic farming are that when farming in buildings there is no need for pesticides, herbicides and there are no growing seasons that restrict farmers and what they can produce. The main problem that hydroponic farmers face is that sometimes the water systems need to be flushed which is a waste of water and nutrients and money. With nutrients being a very expensive expenditure and water being a scarcity, this is an unwanted byproduct and downfall of hydroponics.

Outside of the plant spectrum, there is aquaculture, e.g. farming fish. To meet the increasing demand of the market when wild supplies of fish are becoming harder and more costly to come by, freshwater fish such as tilapia, catfish, and sturgeon are raised in tanks on farms. Farm raised fish are kept on a constant diet and are available for immediate processing to produce a predictable supply. The downside to this method of farming fish is that fish produce a lot of nitrogen and waste which requires extensive filtering. The filtering required is an expensive process and potentially hazardous if a step is missed risking the entire stock of fish.

While aquaculture and hydroponic farming have significant benefits, they also have significant downfalls that have kept them from mainstream practice, but in applying ecology, farmers have found that they could combine the two methods of farming and eliminate all of the downfalls of both because each completes the ecological cycle of the other. In a balanced

Aquaponics system, a farmer can grow fish food, produce, and raw materials for the market. The fish eat the food and pass it through their system, and the ammonia-rich waste is pumped through bacteria biofilters which oxidize the waste transforming it into a nitrate-rich nutrient solution that gives the plants all the food they need and goes back to the fish as clean water. Because of this system of recycling farmers have seen savings in water usage of up to 90%.

With a farming system such as this introduced into the education system, it would require an experienced staff to run, maintain, and facilitate innovation. Due to its controlled environment, predictable production arc and its ability to be modular, educators can adjust curriculum so that a farm is a tool and not a liability. Furthermore, by understanding the opportunities given by a farm of this nature, students can have a viable direction to work towards at any age. The scope of these skills along with any desire to specialize in a field can help give young adults who grew up with this curriculum experience in researching, learning, and communicating while identifying a skill or set of skills that that can be used for tools in life. Some of the skills required for maintaining, marketing, and evolving aquaponic farms are:

- Chemistry- At a basic level, Aquaponics creates an ecosystem that requires a water chemistry. Ammonia, nitrite, and nitrate are created in the system and need to be monitored and maintained requiring an understanding of each step of the process so steps can be made to keep everything balanced. At more advanced levels, research and testing could be done to: grow plants that have different nutritional needs, feed farms with sewage water, figure out how farms could create potable water, create materials and resources with leftover plant and waste matter, etc.
- Engineering- Beyond the basic aquaponics garden kit that can be made and maintained by a hobbyist, or a commercial system which is streamlined for efficiency and profit

there are the opportunities to explore in an educational environment. Learning from these basics students at a young age can test develop an understanding of career level aspects of engineering and even help evolve aquaponics. It is the only method of farming which is it own portable ecosystem.

- Programming- The use of computers and robotics in aquaponics to maintain and harvest farms is a foreseeable future to plan for. This future offers the opportunity to start thinking about software design and development that assist in everything from helping maintain or run the farm to distribution and marketing.

- Genetic- Some plants do not do well in certain environments, some plant do not yield enough to make them cost effective to grow, but they are still a commodity so by working with and understanding even basic genetics, for instance, cross-pollination. Can plants grow in zero gravity? Do some do better than others? Why? Can we takes aspects from one plant and merge them with another to grow plants in space efficiently?

- Robotics- As did the car assembly line move from skilled labor to robotics, so can farming. In fact to keep costs of food down robotics will play a key role and state-funded schools could help develop these technologies so farmers can afford to buy them. The can monitor temperature, humidity, harvest, plant, move resources from one area to another and be essential

- Plumbing/fluid dynamics- Aquaculture farms can have many layers of growing space on a given floor and can occupy a skyscraper greenhouse so this require at its most elementary level the need to transport water from point A to point B. Like

with robotics, this gives children the opportunity to learn vocational skills as well as problem-solving and strategy. The reason why these farms only use 2-10% of what a traditional farm does is because they recycle water. Even condensation is collected and put back into the system. Fluids and waste need to be segregated, collected and processed.

- Electrical-To run an aquaponics system there needs to be minimally pumps and lights, but can easily grow into needing to build and maintain power systems for robotics, computers, sensors, valves, temperature, etc. students will learn fundamentals of electricity and put it to practice.
- Structural-water and plants weigh a lot and as they are stacked on top of each other, and more floors are built and questions are asked. How does one make a structure that can hold that weight and survive an earthquake/ tornado/ hurricane? Does this structure retain too much heat or not enough and how do we fix it?

- Management and Marketing
  - Art and Digital Media- There can be no farm if there is not a market and the market is influenced by the outward appearance and advertising educating and enticing the public. From brand names and insignias to YouTube and Facebook advertising videos, introducing latest technology, there is a lot to learn.
    - Communication
    - Music

    - Economics- While this is an area that needs to be managed by professionals in real life, there is ample room for mentoring. The market is the grease that keeps the wheels of opportunity and invention turning.
        - Business
            - Investing
            - Money management

- Cooking
- Ecology- By default in learning how to manipulate and manage an ecosystem in a controlled environment students need to look at the natural world as a model. Just because aquaculture farms are removed from the wild environment of the outdoors does not diminish its need for an understanding of the natural world
- Research- It could be argued that learning the ability to research is more valuable than learning what one is being told. Aquaculture is a living and growing science which inspires extensive research into every aspect. A lack of imagination is a student's only limitation.
- Conceptual design- Food systems, cities, towns, art, environment and technology are ever changing. Taking aquaponic farms to new levels allows for creativity within and outside of the farm. Cutting edge and innovative engines of imagination

Business Benefits-All Aboard! Better Jump On, Trains Leaving the Station

Education is fluid. There is very little in life that needs to be known when compared to what is available to be learned, and it is this very concept that makes education expensive. Preparing children to enter the world and fill our shoes, learn from our mistakes, fix our problems, make discoveries and teach the following generation how to do the same demands a system of education that can keep pace with evolutions of life by education itself being alive. Current models of education are monuments to our inefficiency; money is spent, not to overhaul the system but to add more school. As the world grows in knowledge, we add another level of college required to function in society. Students are brought up so far from reality that by the time they get to college, many do not have a vetted path. We pay and pay and pay with the limited tax dollars that each the district and school receives so that students can explore college preparing for the world which is largely out of sync with the student. So, while traditional gardens do measurably help improve students' performance in ideal situations by offering hands-on interactions with ecology and are a tool for the sciences, they fall short of being a good investment. Garden programs have said that they can grow food for the cafeterias to help save money but budgets run in the negative. After factoring in wages, water, seed, what the kitchens can process, and the growing season taking place largely when the kids are on break, and the weather being unpredictable especially with global warming school gardens run in the red. The only financial support comes from those who want to help because it feels good or because they

receive tax breaks. In the long run feeling good is mute if it is a practice that runs itself bankrupt and always operates in the red.

Agriculture is the core of our society. We can rid ourselves of virtually every other specialization and agriculture will keep the community and inspire what we initially removed. Understandably a person would see this and want for this core of society to be taught in schools because without it society falls apart. However, what kind of foundation for a modern interpretation of education can be created with agricultural practices that are nearly as old as community itself? Human and industrial needs are different than they used to be. We have a better understanding of health, a smaller world with a broader sense of community. Technology has exponential growth creating environments where the job market in the next 20-50 years could become something that we do not recognize today. Will traditional farming build a foundation in education that we want to rest our retirement on? To rest our kids future on, to surrender our country to when it is time to pass the torch and let those we raised support us?

Aquaponic farms are a gamble, yes, they have a high initial cost and require year-round skilled monitoring and care, they are in many ways the new kid on the block, but that new kid on the block is a hybrid. The best of the best and can just keep getting better. The real-time opportunities and experiences that an aquaponic farm can create are real. James Ehrlich, Senior Technologist at Stanford University, Senior Fellow at Opus Novum consortium at NASA Ames and an Entrepreneur in Residence at the Stanford Peace Innovation Lab at the Center for Design Research has started Stanford University spinoff company called ReGen which designs and builds eco-villages each built on a closed loop water supply with and aquaculture foundation. These villages are self-contained, and the closed loop water system takes human waste and has been able to convert that into plant food which cleans the water. In scale models of this closed

looped system farms, of the water initially put into the system, after three years 85% of the water started with is still in the system (Ehrlich, 2017). Even Prisons are getting aquaculture farms installed such as in Denver County Jail. “The benefits of this unique project are seemingly endless and bountiful including; growing a portion of the prison's food needs on site, utilization of inmate labor to construct and maintain the system which leads to education and job training skills [and] rehabilitative work that emphasizes care for living organisms,” while producing around 600 pounds of fish and nearly 7000 heads of lettuce monthly(White/Anderson, 2014). With the right marketing, production levels and distribution channels farms could be built that not only pay for themselves but provide supplemental income for the schools while giving students a more intimate education and life experience that would help establish everything that makes them not ready for adulthood today.

Summary-If You Didn’t Catch it the First Time

The introduction of aquaponic farms will not be easy or cheap. When implementing a school garden, the process roughly requires breaking up the earth, planting cover crops, go through a season preparing the soil and then turn it into beds and start growing, or add amendments to the soil or build boxes and fill them with potting soil for a more immediate plug and play garden. In the grand scheme of things, it is a very low cost. There is a multitude of resources available for districts, principals and teachers to use online, such as the guide from Ecolitereacy.org which provides a k-12 lesson plan. However, not every school has an environment to have a garden. Most of the growing season takes place when kids are out of

school for the summer. It is not modular in design, and each school will face different challenges, not offering a unified benefit from this resource.

Comparatively, aquaponics has more moving parts, more initial investment because an ecosystem is being built. However, Aquaponics has the potential of not just being another way to farm, but a leading way to farm. It is modular; the parts can be purchased in bulk to build the same system in every school, all it needs, minimally is space or a room and electricity. The Aquaponic gardens can be scalable to the class size. The growing season is year-round the outcomes are predictable/ measurable. Because of its modular design and versatility, a standardized curriculum could more readily be established. Because of the initial complexity and its mimicry of the ecosystem, students will have access to more opportunities for learning which will only grow.

California is the leader in food production in this country producing "more than 400 commodities. Over a third of the country's vegetables and two-thirds of the country's fruits and nuts are grown in California," with a revenue of approximately $47 billion dollars annually (California,2015). California has also faced a significant drought, and 60 percent of the water used on farms comes from groundwater. Outside of California, western states rely on the Colorado River basin and the Ogallala Aquifer and 40 other aquifers. The water in these aquifers is depleting faster than it is refilled and is expected to go dry around 2040, right when the peak of food production is expected (Plumer,2013). Aquaponics can use up 10% of the water a traditional farm will use and can grow up to 9 times more produce per square foot annually. As a hegemonic power, California/America has a responsibility to the world and our children to anticipate their needs in the future. We can do that in good conscious by divesting ourselves of time and money out from a 10,000-year-old practice that has dug us into a hole that can bury our

children and grandchildren. Alternatively, we can invest in a new idea of education that is a modular platform from which a variety of life skills could be taught. A platform which gives them a core understanding of how to create more with less. A platform which will allow our children to be industry leaders in agricultural technology and pioneers of resource production. A platform that prepares students for life and higher learning. A platform that supports current investments in agriculture that will be cornerstones of civilization. The answer is obvious, but the steps to implement are new and need to be pioneered.

Call to action- Bold Baby Steps

For this to work we need to meet with educators and established aquaponic farmers to design a system that can be managed and upgraded by students and at least two full-time farm facilitators. A curriculum needs to be made around this farm and tested so results can be shown to the public and to government representatives so that real evolution of the k-12 educational requirements can occur.

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