Incorporating Hydroponics into Academic Curriculum to Promote Education and Food Security in Developing Nations

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

As global populations soar and natural resources remain constant, we are constantly in search of new agricultural technologies that can be leveraged to increase the food supply and food security for people around the world. One promising agricultural technology is hydroponics, which is a method of growing plants without using soil by instead using a supplementary nutrient mixture (Aires, 2018). Hydroponics may benefit places such as developing states, which face immense food insecurity due to geographic location and socioeconomic status of locals. Through the use of hydroponics, these nations will be able to increase domestic food production, thus decreasing reliance on volatile food imports. However, many local farmers may be reluctant to adopt hydroponics as it is a new and foreign technology. Through research, I have found that incorporating hydroponics in an academic curriculum can be extremely successful (Boston College, 2017). Young students are excited and eager to get involved in a hands-on activity, and combined with the right measures, implementing hydroponics in a curriculum can provide a unique education as well as a nutritious food source for school children and staff (Stajano, 2004). Through further research, I will analyze current hydroponic curriculums in order to ascertain what factors or combinations of factors lead to a successful program. Factors covered include appropriate age level, academic environment, and teacher involvement.

Background

Developing nations can leverage new hydroponic crop cultivation techniques in order to provide a consistent food supply for their inhabitants. Growing crops with hydroponics provides many benefits relative to traditional forms of agriculture, such as increased crop yield and conservation of both land and water (Aires, 2018). Hydroponics uses 95% less water and food

waste, 94% less fertilizers, 99.9% less transportation, and 71% less carbon emissions (Oleson & Smith, 2018). For many developing nations, domestic agriculture is essential to maintaining a consistent food supply for its inhabitants, thus locals are a crucial stakeholder to any structural changes in the food supply chain. As an example, in the 1940's, the US Air Force used hydroponic technology to provide produce for troops in small nation states in the Pacific (Ortiz, Rotatori, Schreiber, & von Roth, 2009). In order to best maintain a hydroponic initiative in a developing state, the "farmers" must be carefully chosen. Hydroponics seem unfamiliar and unconventional to seasoned farmers, thus it can be favorable to target and educate youth, who are open and excited to try new things (Boston College, 2017).

Several case studies suggest that incorporating a hydroponic unit within an academic setting can teach the students about hydroponics and offer several additional benefits. First, understanding the science behind a hydroponic unit can increase the success of the technology (Resh, 1997). By learning about hydroponics in the classroom, students will be educated on the entire process, from setting up the unit to harvesting crops; thus, they will be able to troubleshoot, make improvements, and more. These hands-on hydroponic lessons also provide a food source for students who may not have a stable food supply at home (Boston College, 2017). Additionally, if structured correctly, the curriculum can cover many academic areas, including match, science, history, and business skills (Ortiz et al., 2009). A hydroponic program can also facilitate "cross-departmental collaboration opportunities," encouraging science teachers, agriculture teachers, and even food service employees to work together (Reality Works, 2019).

There are many factors that may contribute to the success or failure of a hydroponic initiative within a school. First, it is important to consider which school level a program may work best at. From kindergarten through high school, students have different needs and interests,

thus it is vital to understand the target students when planning a curriculum. Additionally, the nature of the program itself is important, specifically whether the education will be mandatory during a school period or as an optional after-school activity. It is also critical to decide how involved the teachers will be, or conversely, how much independence the students will be given. I will focus on these three factors: student age, teaching environment, and teacher involvement throughout my research.

Data Collection and Analysis

The majority of my data collection will be searching online databases and search engines in order to find adequate literature and research to support and enhance my exploration. Collecting data will involve detailed and in-depth note taking and documentation of appropriate sources. Once the information has been collected, I will analyze the content of these sources. This will help me draw comparisons between different hydroponic academic initiatives, thus I can discern factors that lead to the success or failure of a certain program.

Literature Review

Several case studies have proven that incorporating hydroponics within an academic curriculum can be a useful and beneficial learning tool. When the students are maintaining and collecting fresh produce from their own unit, they become more invested in the project and may learn more as a result of this excitement and involvement. I will discuss several case studies, the first of which involved integrating hydroponics into the curriculum for Kindergarten students in Uruguay.

At a school in Uruguay, Kindergarten students, aged four to five, were introduced to the concept and technology of hydroponics through lessons and hands-on activities in 1999. For the

program, four teachers and one coordinator worked with two separate groups of 35 children (Stajano, 2004). Martin Stajano, the president of the Uruguayan Hydroponics Society believed hydroponics were a great choice for an agricultural curriculum because it does not require a lot of space, and students can be directly involved with the project through the entire growth cycle. Choosing plants that grow fast can be useful so that young children stay interested and engaged. Mid-way through the program, the school hosted a discussion where parents and families could come learn about the project (Stajano, 2004). This event helped develop the self-esteem of these young students, for they felt proud of their direct involvement with the unit and its crops (Ortiz et al., 2009). Additionally, incorporating this educational program at a young age helped teach the children about healthy eating habits. When the students were able to pick and eat their own produce, it was an exciting moment for all. 93% of parents reported that their children were excited and motivated by this experience (Stajano, 2004). Overall, incorporating a simple, hands-on hydroponic initiative in a Kindergarten class can be very successful. Next, I will discuss a case study at a different age level, which occurred in an Alaskan high school.

At a high school in rural Alaska, nine high school students worked on a hydroponics initiative, spending 32 hours each week dedicated to the program (Ortiz et al., 2009). This specific project aimed to partner the school with local businesses, thus giving the program an entrepreneurial twist. The main takeaways from this case study are that older students, of high school age, are more likely to become excited and involved with a hydroponics program if it can offer them business skills as well as science and agriculture (Ortiz et al., 2009). By partnering with local businesses, the students were able to grow vegetables that they then sold to a local restaurant. The students learned about marketing, communication, sales, and more through this experience. Additionally, with a higher education level, these students were eager to experiment

with different variables, such as amount of nutrients, amount of water, and type of crops (Ortiz et al., 2009). By allowing the students to be as active as possible, they become more interested with the program. This phenomena parallels what we saw with the Kindergarten students in Uruguay; however, with high school students, the responsibility that they are given should be much greater to maintain interest.

Finally, I researched an after-school hydroponics club in order to better understand the advantages and disadvantages of offering hydroponics as an optional activity. The school, Wat Pathumwanaram School (WPS), was a K-9 school in Thailand home to 700 students (Thornton., Indruh, Anderson, & Kauffman-Rogoff, 2010). Previously, the purpose of this hydroponics garden was to grow and sell produce as a form of income for the school; however, now, the shift is moving towards education. Initially, the crops were only watched by a few students and one teacher. As the focus grew towards education, more students than ever were helping with the garden, which, in turn, boosted its success. Many students were able to strengthen their "critical thinking and analysis skills" (Thornton, et al., 2010). Several measures were taken both to attract new students and keep current students involved. The hydroponics club at WPS was made more sustainable by incorporating student leadership and regular team meetings. Students were able to run for a leadership position, and once chosen, the executive members enjoyed having a direct impact on the project (Thornton, et al., 2010). By giving students a chance to claim a leadership role, the club became more attractive. Additionally, hosting regular team meetings helps stabilize the club and give students some structure. Finally, this hydroponic program can help poor neighborhoods by exciting and motivating the children academically (Thornton, et al., 2010).. With increased school attendance, more students will continue on to higher education, in turn stimulating the local economy.

Increasing the Success of a Hydroponic Program

It is evident that incorporating hydroponics into an academic curriculum can be beneficial for several reasons. To optimize success, I will present suggestions for modifying certain components of the program, including student age level, the academic environment, and the teachers' involvement.

Student Age Level

Several case studies confirm that a hydroponic initiative can be successful for multiple age groups. The Uruguayan students were in Kindergarten, aged between 4 and 5, whilst the Alaskan High School program targeted students ages 14 to 18. Additionally, the program at WPS was offered to all students, from Kindergarten students to high school students. My research confirmed that a successful hydroponic program is possible for multiple age groups; however, I learned that there are small changes that can be made to tailor the program to a certain age group. At a glance, a Kindergarten curriculum should remain simple and enjoyable, whereas with high school students, the responsibility that they are given, along with the intensity of the curriculum, should be much greater to maintain interest.

Introducing hydroponics to young students reveals several benefits. The students will feel a sense of accomplishment, and they will learn about hydroponics and healthy eating habits at a young age, which can propel them to continue studying agriculture (Stajano, 2004). Research by Boston College has proven that young students who participated in a hydroponics program "developed positive attitudes toward science, less anxiety and greater self-confidence" (Boston College, 2017). Additionally, young students are 'sponges' in the sense that they absorb new information quickly and with excitement. This phenomenon can improve the success of the

program because students will be eager to get directly involved with a hands-on project that produces real fruits and vegetables. Older students experience similar feelings, but at a smaller scale, and they often need more incentive to participate. High school students are more educated; thus, they will desire more freedom to experiment with the hydroponic unit and make their own decisions (Stajano, 2004).

Therefore, with a hydroponic curriculum, there are actionable changes that can be made to the program to boost the success for a particular age group. Younger students should be given a light curriculum with an emphasis on the hands-on, fruitful nature of using hydroponics. Conversely, a hydroponic program will be more successful with older students if the curriculum is more advanced. This curriculum should emphasize entrepreneurship, business, and decision making to better appeal to more educated students (Stajano, 2004).

Academic Environment

Another factor that affects the likelihood of success for a hydroponic curriculum program is the academic environment. Specifically, I researched two separate environments. The first teaches hydroponics as a mandatory program within a science classroom. The second is an optional out-of-school time program, where involvement is voluntary.

Of course, each option has its advantages and disadvantages. In-school programs guarantee that a predetermined number of students will be given the opportunity to learn about and become responsible for a hydroponic unit. However, we cannot predict the level of engagement the students will contribute, since they don't have an active choice in participating in the hydroponics program. Thus, research recommends that to promote the success of an in-

school program, the curriculum should be both exciting and adaptable in order to tailor to all students.

On the contrary, after-school programs have become more and more popular, as demographics have shifted towards “more single parent households and two-family working couples” (Hein, 2009). When programs are voluntary, it is more likely that the student has a passion or interest regarding the topic, and thus he or she will likely put in more hours and focus to ensure a successful harvest. According to Afterschool Alliance, a well-renowned national afterschool program, there are proven methods to improve the success and quality of an afterschool program. First, there should be a presence of activity variation. Students want to be challenged, excited, and provoked; by switching up the activities, the after-school program can be more successful (Afterschool Alliance, 2014). Next, there should be a “sufficient dosage” of the program, meaning that both high attendance and engagement are vital towards success. Finally, the program needs to be well organized, with well-defined goals and activities to provide the students with structure (Afterschool Alliance, 2014). Hosting regular club meetings can also promote structure for the program.

Teacher Involvement

Finally, teacher involvement is an extremely critical component for the success of a hydroponic program.

There are many actions and precautions a teacher can take to engage students and improve the curriculum's success. First, teachers should give students more control, especially with older students. As seen in the Alaskan High School case study, when students are able to create and dictate their own experiments, it “makes them more likely to be interested and motivated to work with the hydroponic system” (Ortiz et al., 2009). To promote interest, teachers

should always be well prepared for class and attempt to incentivize interest for students (Harackiewicz, Smith, & Priniski, 2016). As an example, students often are motivated to participate in a project that gives back to their community (Harackiewicz et al., 2016). Teachers could stress the potential benefits of hydroponics for feeding a community in order to spark students' excitement. Next, research has shown that a teacher can promote the program by hosting a mid-project discussion and inviting parents and family members (Stajano, 2004). At these discussions, the students can show off their hydroponic produce and explain the concepts they have learned, which helps build confidence, especially for younger students (Ortiz et al., 2009).

Additionally, research by Boston College indicates that a hydroponic program can be quite successful regardless of the teacher's knowledge on hydroponics. This finding is promising because many after-school programs are run by instructors with minimal science experience (Boston College, 2017); thus, an after-school hydroponic program can be prosperous even if the instructor has limited science knowledge. The study found that the most basic version of their hydroponics curriculum could thrive amongst a wide range of teachers, proving the curriculum "can be scaled to any number of contexts where teachers have little science, or teaching, experience" (Boston College, 2017).

There are also measures a teacher can avoid in order to improve the program. First, the teacher should ensure they are not "overloaded with other duties" (Patchen, et al., 2017). If a teacher is swamped with additional responsibilities, this may inhibit the success of a hydroponics initiative, and the school should encourage a different teacher to promote the program. Additionally, a successful hydroponics program needs a solid support base from parents and

volunteers, as students are often more motivated when they have external encouragement (Patchen, et al., 2017).

Conclusion

Developing states are often at risk of food insecurity, and thus establishing secure and reliable agricultural methods can improve the quality of life for its inhabitants. Hydroponics is a method of soil-less agriculture that instead uses a nutrient rich liquid solution; thus, hydroponics is ideal in areas where there is poor soil fertility and a lack of arable land (Sardare & Admane, 2013). One major deterrent to the popularity of hydroponics is a lack of education. Thus, by incorporating hydroponics into academic curriculums, the youth of developing nations will be introduced to the agricultural technique and hopefully carry this knowledge with them into their communities.

Several case studies have proven that integrating hydroponics within an academic curriculum can be an effective and constructive learning tool. Through my research, I recommended strategies to create an efficient and powerful hydroponics program, focusing on several factors that may affect program outcomes. These factors are age level, academic environment, and teacher involvement.

With regards to age level, I found that it is possible to teach hydroponics to students of all ages, but minor adjustments should be made to tailor the curriculum (Stajano, 2004). Younger students should receive a simple curriculum with an emphasis on hands-on activities, whereas older students should be given a more advanced curriculum focused on entrepreneurship, business, and decision making (Stajano, 2004). Next, I analyzed different academic environments and found that both mandatory, in-school hydroponics programs and optional,

after-school programs can be equally successful. For in-school programs, the curriculum needs to be adaptable to a larger range of students, thus the activities and lessons should be flexible in order to engage more students. Students can also be broken into smaller groups based on areas of interest. With regards to after-school programs, since participation is voluntary, the program will need structure. For example, the instructor can promote student leadership as well as scheduling regular meetings. Finally, varying levels of teacher involvement can affect the success of a hydroponic program. Teachers should let students have some control over the projects, and they should continuously incentivize interest throughout the curriculum.

Using these suggestions, it is quite feasible to incorporate hydroponics into an academic curriculum in order to promote education and food security in developing nations. With a newfound grasp on hydroponics, students can take this excitement and knowledge and pursue a career in agriculture, boosting domestic agricultural production for their community in the long run. Additionally, the harvested produce from the hydroponic unit can provide food for the students, faculty, and staff. Utilizing hydroponics within education is a large step towards a self-sustaining future for developing nations.

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