A Qualitative Assessment of Considerations on How Teachers Can Use Classroom Growing Systems as a Teaching Model in Middle School Classrooms

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Abstract

For many schools, the opportunity for more time to teach health continues to be a struggle. School gardening programs come as a result of farm-to-fresh initiatives that aim to link students with food production, increase access to healthy and local foods, and serve as an educational opportunity. The purpose of this study was to examine how one type of growing system, aquaponics, can be used as a health education teaching model within middle school classrooms. Participating middle school teachers (n = 17) attended three interactive workshops focusing on how to integrate the growing systems into their classrooms. Researchers administered semi-structured interviews using open-ended questions focusing on integration and implementation strategies, aesthetics of the systems and how they fit within their classrooms, and overall system functionality. Three specific themes emerged from participant responses: increase in experiential learning; learning about ecosystems; and lessons learned from implementation. Health educators can use growing systems to teach about healthy ecosystems and nutritional behaviors in a learner-centric environment using interactive activities that promote the development of higher-order thinking skills.

Introduction

Schools are ideal settings to instill healthy behaviors due to student reach and the ability to explore health education topics within a learner-centric environment. However, the amount of time a child spends in the classroom at school, along with involvement in extracurricular activities, makes it difficult to create an additional learning space where children can focus on personal health. Rates of childhood obesity continue to rise, and for many school leaders, the opportunity for more time to teach health education continues to be a struggle (Ogden et al., 2014). Presumably students are taught the skills necessary to be active during physical education classes, but many schools lack a dedicated health education program, potentially ill equipping students to live a well-balanced lifestyle (Blom-Hoffman et al., 2008). Often if nutrition and health is discussed

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outside the constraints of a dedicated health class, it is done within science classes as a short unit or only taught at a single grade level (Jaenke et al., 2012). The problem of finding instructional time for health education within already packed school day has led to the creation of innovative health education interventions such as gardening programs.

Gardening programs come as a result of farm-to-fresh initiatives that aim to link students with food production, increase access to healthy and local foods, and serve as educational opportunities. Gardening programs encompass a public health agenda and facilitate student engagement, incorporate nutrition education, serve as a mode of physical activity, and enrich psychological well-being (Irvine, Johnson & Peters, 1999; Parmer, Salisbury-Glennon, Shannon, & Struempler, 2009; Twiss et al., 2011; Wakefield et al., 2007). Some of the most notable impacts include the availability of fresh produce for individuals at a lower cost, an increase in fruit and vegetable consumption, and the influence on a person's attitude creating a preference for healthier foods (Contento, Manning, and Shannon, 1992; Ratcliffe, Merrigan, Rogers, and Goldberg, 2011; Somerset & Markwell, 2009). Gardening programs can serve as a platform for school growing programs that encourage students to grow their own food in hopes that someday the subsequently grown produce may be served in school cafeterias.

Growing programs are comprised of multiple components, including how systems fit within the environment, stages of produce growth, and contributing factors of growth (lighting, growing media, and pruning). The varying components of growing systems provide flexibility for teachers to instruct a specific topic as it might relate to an existing subject within their curriculum (Irvine, Johnson, & Peters, 1999; Jaenke et al., 2012). Growing programs provide a platform to connect children to the food they eat and facilitate understanding of where and how food is grown (Jaenke et al., 2012). Growing systems are gaining popularity, can be impactful, and can have a direct influence on children's health (Parmer, Salisbury-Glennon, Shannon & Struempler, 2009). Health educators can harness the interest in growing systems and use them as a teaching tool by encompassing health lessons and activities in these programs.

Integrating Growing Systems in the Classroom

While educational goals have not changed, the roles and responsibilities of educators have (Valli & Buese, 2007). Educators possess the unique role of not only increasing student understanding of challenging concepts but also helping to shape student behavior and instill positive habits within the school environment. Programs that are designed to maintain student interest in and motivation towards learning science can be challenging for educators to implement in classrooms. Program costs and lack of time in the school day are key barriers associated with program integration in schools (Linn et al., 2002; Valli & Buese, 2007). Many schools do not have the financial resources to implement extensive programs, and teachers have less time due to additional school responsibilities (Valli & Buese, 2007).

Gardening programs present a less costly option that encompasses many concepts of science, providing the adaptability that allows teachers to pick and choose specific pieces to be integrated into existing curriculum (Dilafruz, Williams, & Dixon, 2013). Gardening activities align with components of life science, ecology, chemistry, and physics, creating links for instruction. Additionally, the more tangible products of gardening can be used to teach various topics in health education (Wakefield, Yeudall, Taron, Reynolds, & Skinner, 2007). The links between science and gardening allow educators to use gardening programs as a potential teaching tool that can be used to impact student health directly or indirectly.

The skills associated with and acquired through gardening or similar growing programs can transfer into behaviors that promote healthy lifestyles. These associated skills can be used as a tool for health educators to approach health topics among an important population through innovative tactics. Gardening allows students to explore new concepts in an interactive environment, discover ideas, learn from peers (role modeling/observational learning), and build behavior efficacy (Fryling, Johston, & Hayes, 2011; Greer, Dudek-Singer, & Gautreaux, 2006). Information and skills learned through school gardening programs can bolster students' health and well-being. Building healthy lifestyle behaviors has shown to have positive benefits for both children and adults (Alaimo, Packnett, Miles & Kruger, 2008). The combination of science and health with the acquisition of life skills could reinforce behaviors that promote lifelong health habits. These components are important for health educators because growing systems are a popular trend that continues to generate momentum because of their versatile application and implementation (Clayborn, Medina, & O'Brien, 2017; Genello, Fry, Frederick, Li, & Love, 2015; Hart, Webb, Hollingsworth, & Danylchuk, 2014).

A barrier for many health education interventions is determining how to integrate growing systems in classrooms. This current study focuses on aquaponics growing systems, which are state-of-the-art, efficient growing systems that combine horticultural and aquaculture practices. These growing systems can easily be managed within a classroom to produce fruit, vegetables, and fish. Aquaponics systems offer a unique way to incorporate agriculture and biotechnology into an educational model (Genello et al., 2015; Hart et al., 2014). Further, aquaponics systems are different than traditional growing systems as they incorporate fish. As a combination of hydroponic and aquaculture systems, aquaponics systems eliminate many of the negative aspects associated with each individual agriculture method. Fish waste provides adequate nutrients for plant growth and eliminates the need for chemical fertilizers. Plant waste provides adequate water chemical conditions for promoting fish life, while the plant bed media provides filtration, eliminating the need for a traditional tank filter.

These systems can be integrated fully indoors and do not require large amounts of space or the resources necessary for traditional gardens, making them ideal for classrooms or small spaces (Genello et al., 2015; Hart et al., 2014). The adaptability of aquaponics systems alleviates time restraints because it allows teachers to use the growing system as a teaching model. Aquaponics systems have been used to help students with math and science concepts. Health education topics are among the easiest to intertwine with system instruction, such as benefits of fresh food as it relates to health (Clayborn, Medina & O'Brien, 2017). Aquaponics systems also create a platform for health components without the need for additional materials or time-consuming set up required for extracurricular classroom activities. Aquaponics systems can be an effective modality for health educators to address a variety of health education topics and skills that can contribute to increasing the health knowledge and behaviors of students in the classroom (Hart et al., 2014). The purpose of this research study was to examine how aquaponics growing systems can be used as a health education teaching model within middle school classrooms.

Research Question(s)

1. How can teachers use a classroom growing system as a teaching model for health education?
2. Will using an aquaponics growing system enhance the instruction of health education?

Methods

This study was approved by the primary investigator's institutional review board (#050817-1).

Participants

Study participation was offered at the final meeting of a three-series growing school program workshop hosted for rural middle school science teachers. A total of 17 middle school teachers participated in the current study. Participants represented 13 different schools located in rural Nebraska. Each participating teacher received a fully functional aquaponics growing system and all materials necessary to integrate, run, and maintain the system within their classroom. Participating teachers each attended three interactive workshops focusing on (a) how to maintain and sustain their growing system, (b) how the growing system can be integrated into state education standards, and (c) how technology can be interwoven into the maintenance of a functioning system. If participants chose not to participate in the study, they were not penalized. Teachers were encouraged to integrate the aquaponics growing system into health, science, and technology topics in their classrooms.

Aquaponics Growing Program Workshops

Participating schools each were provided a fully functioning aquaponics growing system. During the first workshop, teachers were provided a list of produce they could grow and were encouraged to include student input in choosing the type of produce grown. Each teacher received a tank, tilapia (Allied Aqua, Smithville, MO), fish food (Tilapia PowerStart Fingerling Crumble), water pump, tubing for water distribution, a standing growing bed, growing media, grow lights, a power surge, and a timer for grow lights. Each system was designed under the same premise and teachers were encouraged to put their unique stamp on their system. Further, a list of instructions and implementation strategies were provided to teachers that included ideal water and room temperature, system location, and tips for optimal growing. A graduate research assistant served as the technical assistance liaison and was available to help replace parts (as necessary), deliver fish, or help with potential implementation or maintenance problems. Participating teachers implemented the aquaponics growing systems in their classrooms for the duration of one school year.

Procedures

A qualitative assessment was conducted during the final workshop following one year of growing program implementation. The assessment used the following sequence: (a) project introduction and purpose; (b) informed consent completion; and (c) semi-structured interviews. Each participant was provided a notepad to record specific comments or experiences pertaining to system integration and implementation (Greer, Dudek-Singer, & Gautreaux, 2006). Participants were asked to return their notes to the research team. During the semi-structured interviews, researchers asked open-ended questions that asked about: integration and implementation strategies, aesthetics of the systems and how they fit within their classrooms, and overall system functionality. Data were recorded by having each participant write and return their answers to researchers. Example questions included: (a) What did you find difficult about integrating your aquaponics system into your existing curriculum; (b) What would you have changed about the design of your system (lighting, height, size of bed, growing media, etc.), and (c) How did students help maintain the system? In addition to the aforementioned questions, follow-up questions were asked to provide more clarity. Casual conversations about participants' experience guided discussions. Researchers documented participants' verbal responses, nonverbal behavior, and copies of notes. Nonverbal cues included those of like or dislike (e.g. smiling or body language) concerning their experience with the aquaponics growing systems in their classrooms.

Data Analysis

Qualitative data were analyzed following the Merriam's (2009) principles. Following this process, notes, taken by the researchers during the workshop, were compared, and open coding took place to identify ideas about themes or relationships among themes. After open coding, ideas were analyzed and sorted to identify overarching themes. Through an iterative process, these themes were then combined, narrowed, and adjusted to determine final themes. Triangulating the analyses contributed to the reliability of this study as both researchers were involved in data analysis (Merriam, 2009; Patton, 2002). Three common themes, described in detail below, emerged from this triangulation of analyses.

Results

Three specific themes emerged from the participant responses (n = 17) that included: (a) increase in experiential learning; (b) learning about ecosystems; and (c) lessons learned from implementation.

Increase in Experiential Learning

The majority of participants (n = 16) discussed how the aquaponics growing system increased experiential learning opportunities for the students in their classrooms. Experiential learning is an important teaching strategy to incorporate into health education classrooms to improve the student learning. The aquaponics growing system allowed students the ability to interact with the system and see how multiple organisms work together in a community to produce life-sustaining products. Multiple participants said this system connected teaching in the classroom to the outside world by providing real-life hands-on experiences for students. One participant stated, "students looked forward to observing and feeding the fish." Participants mentioned that students were very interested, engaged, and intrigued by the system and how it works. Another participant said, "students enjoyed them (aquaponics system activities) and they took ownership." Finally, one participant stated, "the system allowed students to see how organisms work together to produce life-sustaining products and succeeded in keeping students interested."

Learning About Ecosystems

In this study, the majority of participants (n=15) explained that their students understood the water cycle, nutrient cycle, plant growth cycle, energy transformation, ecosystems, filtration systems, and photosynthesis concepts better when they were able to apply the information from the class to what was happening in the aquaponics growing system. One participant said, "The system naturally goes with ecosystems." Another participant stated it helped students understand "the urinary system of the human body", as the participant equated the plant media bed to the kidneys. The system easily can be applied to numerous health education concepts and the participants in this study mentioned numerous ways to make the system applicable to the concepts the teachers covered in the classroom. While these participants explained direct uses of the system in the classroom, all the other participants in the interview showed engagement and expressed agreement through non-verbal cues such as head nodding, smiling and leaning forward. Many of the participants scribbled furiously in notebooks when others explained exact implementation as tied with health concepts and yet other participants responded with verbal cues such as, "Great idea!" or "I am going to try that next semester." Finally, one participant said it was easily applied to "photosynthesis, ecosystems, plant growth, and filtration systems."

Lessons Learned from Implementation

All participants (n = 17) mentioned that students must be able to see what is going on in the aquaponics growing system for optimal learning. Participants explained that the system should be placed at student eye level, and the system must have enough lighting so students can see what is happening in the system. One participant was convinced that placing the system at eye level not only better engaged the student audience, but also made the fish "happy". She also expressed that her fish had grown too large for the tank and larger tanks might be considered in the future. To address system visibility, one participant said, "I just needed to put it on the table." and another one stated "I put a base on the bottom of the tank to get it off the floor." As for the lighting, one participant said, "I added another fluorescent tube to the system"; while another participant stated, "I added bright rocks to the system." Not all participants made the adjustments mentioned above, but all participants indicated that these two issues, student visibility and lighting, needed to be resolved to make the aquaponics growing system more effective within their classrooms.

Discussion

In many cases, health education is taught in conjunction with other subjects such as science or physical education. Aquaponics growing systems can serve as an effective means to incorporate health education topics and skills into existing curricula using experiential learning techniques through interactive activities. Experiential learning includes learning through discussion, hands-on participation, and applying information outside the classroom (Wurdinger & Carlson, 2010). Hands-on activities allow students to learn through observing, identifying problems, and applying the content being covered in class to real life experiences (Dhanapal & Wan Zi Shan, 2014). Students in science class were assessed during hands-on learning, and data suggests hands-on activities promote information retention, student participation, and intrinsic motivation toward learning (Dhanapal & Wan Zi Shan, 2014). Growing systems can serve as a mode for experimentation that couples well with both science and health education. Plants respond to different internal and external variances potentially causing significant impacts, much like human health. Parallels between the aquaponics growing system and human growth and development can be examined through experiments including light sources, vitamins, nutrients, pH level, temperature, and water.

Integrated Health Education Topics

Interactive growing systems provide health educators the flexibility to instruct about various components that contribute to human health. See Table 1 for a few examples of the health education topics and skills that can be taught and reinforced by the aquaponics growing system.

Ecosystems are basic units of nature and can incorporate various components including living and nonliving organisms involving both plants and animals (Willis, 1997). Growing systems provide a visualization of an active ecosystem with fish and plants providing the ability for students to analyze, evaluate, create, and synthesize (higher order learning skills) the various influences within the system cycles such as water level, water/air temperature, or light (Anderson & Krathwohl, 2001). Human health ecosystems can be difficult to understand because deviations are not always visible, and changes are gradual. Growing ecosystems provide a model that students can use to examine and assess (evaluate) change. The association between growing healthy food and nutrition is not the only health aspect associated with growing systems. The instructional flexibility provided allows the ability for students to critically examine health indicators and potentially drawn connections between health influences and health outcomes.

Exposure to cues present in aquaponic ecosystems, such as healthy produce, gardening tools, or fish can trigger individuals to be more health conscious of a desired topic such as healthy food options. As children manage a growing system that produces healthy food options, they can draw parallels about healthy foods and nutrition. The benefits of growing systems extend beyond the healthy eating and can influence psychological health as well. Understanding how system variances impact an organism (plant, fish, or human) can positively influence health by providing psychological stability. Von Essen and Englander (2013) suggest that adults who consume an organic diet are better connected to aspects of self-identity, values, and well-being. These benefits not only can complement personal health but also enhance student learning allowing students to focus throughout long school days. The integration of growing systems is not a new phenomenon, but research on school-based growing systems, specifically aquaponics systems are limited. As popularity in growing systems continue to grow, more research is needed to assess discipline specific applications.

Table 1
Example health education topics and skills for aquaponics growing systems

Health Topics	Aquaponics System	Health Education Application
Ecosystem homeostasis	Each component of an aquaponics system is reliant on the functioning of subsequent parts. Failure in one section can damage to other sections.	The interwoven connections between the systems in the human body and impact of system imbalance.
Chemical reactions	Aquaponics system functions are dictated by chemical reactions (Ammonia, Nitrite, & Nitrate).	Oxygen consumption and blood glucose; hormone levels and regulation; and cell function in the human body.
Nutrition	Aquaponics systems have the ability to produce nutritious produce and protein.	The food produced can be used as taste testers and teach the recommended requirements for health benefits. How nutritious food impacts human body function.
Nutrient absorption (cells)	Plants absorb nutrients from roots and produce fuel through photosynthesis. Fish absorb nutrients via water and utilize them similarly as humans.	The human body acquires nutrients for energy, defines metabolism.
Circulatory and Respiratory systems (heart, blood, & lungs)	Circulated water supplies fish and plants with necessary nutrients to survive. Water circulates through the system by means of a system pump.	This mirrors the functions of the heart, blood, and lungs.
Disease control (lymphatic & organ function)	Aquaponics systems have built-in filtration systems using the gravel in the aquarium and media in the plant beds.	The human body's filtration systems include the lymph nodes, lymphatic organs, liver, and kidneys.
Reproduction	Fish will breed in an aquaponics system under optimal environmental conditions.	Human reproduction organs and associated complications.
Food production	An aquaponics system can produce twice as much as a traditional garden. Inputs and outputs are necessary for optimal production.	Products of the human body: excrement, hair, skin, nails, energy, etc. Inputs and outputs are necessary for optimal functioning.
Social interactions	Fish territories within the aquarium, specific social interactions between fish have meaning in fish life (e.g. dominance).	Student interactions with peers, conflict mediation and resolution, are necessary components for healthy relationships.

Lessons Learned

What health educators teach (content and curriculum) and how they teach (pedagogy) are vital for students' success. Regardless whether health topics are instructed as stand-alone topics or integrated with other core subjects, maintaining students' attention is important during the process of learning. Participants reported that the enhancement of system aesthetics would make the systems more appealing to students. The addition of vibrant colors, including colorful fish, gravel, or the use of LED lights, could help maintain students' attention. Aesthetics in education have been shown within the literature to help sustain student attention and aesthetic system additions could prove very useful for teachers when instructing complex subjects like health. Effective teaching occurs when educators encompass a multi-dimensional cultural world of the learner that includes the aesthetics in their educational practice (Ramdhani & Ramsaroop, 2015). Empirical evidence suggests external stimuli increases retention (Rosegard & Wilson, 2013). The use of colors in educational settings have been shown to enhance retention among learners by allowing students to draw associations and improve their ability to encode, store, and retrieve information (Olurinola & Tayo, 2015). In addition, visualization is equally important for student learning and can be a powerful strategy for educators when instructing difficult information (Cifuentes & Hsieh, 2004). Aquaponics growing systems (both aquarium and growing bed) should be at students' eye level. This arrangement could include having a platform or stool available for viewing. An attractive and visual teaching model will aid educators with teaching (pedagogy) and maintaining student's attention to help ensure students grasp the scope of the ecosystem parallels.

Limitations

This study was one of the first to use an aquaponics growing system to teach science and health topics to students and evaluate classroom implementation methods. More research needs to be conducted to determine specific curricular activities related to both content areas and the potential for widespread interest in teaching with an aquaponics system. Another limitation was geographic location, as schools in one state had access to the study and the results might not be generalizable. Potential socially desirable responses should be listed as a limitation, because some participants might have felt they had to report only positive aspects of the aquaponics growing system. This study is reliant on self-reported opinions related to implementing an aquaponics growing system in a classroom, and it assumes that all participants accurately and honestly answered each question during the interviews.

Conclusions

The health benefits of eating a balanced diet is well documented; however, very few children meet the recommended consumption values of fruits and vegetables (Spence, Campbell, Lioret, & McNaughton, 2017). Aquaponics systems provide an opportunity for educators to implement additional health educational strategies into the school environment. Incorporating additional health education lessons into the curriculum has the potential to instill among learners long-lasting behavioral changes regarding their personal health. School growing systems (e.g. gardens) can serve as an effective teaching tool for health educators because of their ability to transform a content-based topic into a "hands on" learning activity, which is a type of experiential learning. Hands-on learning activities, or interactive learning, allow for students to develop higher-order thinking skills, such as analysis, evaluation, creation, and synthesis.

Aquaponics systems are available in various sizes and prices making them accessible and replicable for institutions that have limited resources (Genello et al., 2015). Further, there are an array of templates online illustrating how to build full functioning aquaponics growing systems using refurbished/recycled materials including gutters, PVC piping, and trashcans. The advantage of increased popularity has resulted in innovative systems from buying new or building systems using refurbished/recycled materials making it a reasonable for all sizes of school budgets. The innovative nature of this project is replicable for health educators and can be a valuate tool in teaching a wide array of topics.

Growing systems can be integrated into core subjects, further utilizing teacher's instruction efficiency. Health education topics, such as nutrition and physical activity, can be diffused throughout the core subjects of science, math, and English through modes of lab experiments, measuring growth and system functionality, and serving as a prompt for writing assignments. Some ideas for multidisciplinary activities include comparing the nutrients required for humans and plants, the nutritional value, and the impact of environmental influences. Growing systems create a multidiscipline playground for learning, specifically within health education. Garden-based education interventions have the potential to enhance behaviors that impact the health of a child through the ability to grow and taste fresh produce. The pairing of science and health education provides a unique way for teachers to address health education professional competencies without having to implement a stand-alone independent health program. This allows teachers to better utilize their time and create a multidisciplinary learning environment.

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