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# Evaluating the effectiveness of online instruction for building an ”at-home” aquaponics system

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## Abstract

This study explores the development of an online educational tutorial for aquaponics, aiming to refine instructional design for future research and teaching. The overarching goal is to help academics understand the accessibility of knowledge and the delivery methods of aquaponics information in an online medium. By structuring an effective online learning method, this research seeks to empower diverse learners to engage with aquaponics as a viable method for food production and environmental management. The project evaluates the educational effectiveness of tutorials through surveys assessing student comprehension, engagement, and ease of implementation. Findings will inform future instructional design improvements and contribute to the broader field of online education for aquaponics.

## Introduction

Online education is growing and changing for both traditional and non-traditional students. Educators are at odds with open source, think spaces such as YouTube, TikTok, and various other social media platforms. Thus, new forms of online education are required to keep students participatory in learning as universities move to enhance their online education programs. Standard Zoom calls and meetings no longer suffice for online education as the student population is changing. What once was a population that could solely dedicate their time to schooling, now students are under numerous pressures as they attend higher education. Whether it be family, jobs, financial issues, or even transportation, the challenges are growing for students to be able to capture their education within a standard timeframe. Adding to that, non-traditional student numbers are growing with new student populations over the age of 25 seeking to complete a bachelor's degree or a master's degree. Thus, new forms of online education that can reach a wide array of audiences are required. From this, research is needed to explore digital forms of education for the next generation of college attendees. New formats of online instruction are necessary to engage diverse audiences, particularly as higher education shifts away from passive learning models. Research is needed to explore how digital educational tools can effectively teach specialized topics such as aquaponics, an integrated system of aquaculture and hydroponics. Despite its potential for resource efficiency and sustainability, aquaponics education remains largely inaccessible due to limited instructional resources. This study aims to mend this by developing a structured online instructional framework that attempts to enhance knowledge accessibility and engagement.

# Literature Review

## *Aquaponics Systems*

Aquaponics is gaining interest as an alternative agricultural practice, offering innovative ways to cultivate plants and fish in a symbiotic, controlled environment. Aquaponics, the integration of aquaculture and hydroponics, is an innovative method for sustainable agriculture that presents a unique opportunity to merge biological and engineering principles within controlled-environment agriculture [1,2,3]. This method has potential to reduce resource use, minimize environmental impact, and increase food security [1,2,6]. However, while aquaponics holds potential, many individuals lack the educational resources needed to implement these systems effectively. There still remains a gap in comprehensive online educational tools and instruction designed to teach the complexities of building and managing aquaponics systems [2,3,6]. As interest grows in sustainable food production and agricultural engineering, there is a clear need for online instructional tools. At present, few higher educational programs tailored to teaching aquaponics through semi hands-on, online learning are available. This leaves students and future producers (non-traditional learners) without access to key knowledge that could help them explore aquaponics as a valuable agricultural method. The project aims to bridge this gap by providing detailed, interactive materials that guide learners through every aspect of building and managing an aquaponics system.

The overarching goal of this research is to help academics understand the accessibility of knowledge and the delivery methods of aquaponics information in an online medium. Though the research is not unique in its methodology, the step-by-step tutorial method for an academic setting is an endeavor worth exploring as new forms of presenting information in an online, digital format are needed. This trend is evident with the rise of short form media channels and the accessible nature of knowledge (whether factual or not) presented on various social and streaming platforms. The research seeks to obtain baseline information on individuals' perceptions as to how well they obtain information on building an at-home aquaponics system.

This research is based on a larger endeavor to explore the potential benefits of aquaponics and hydroponics for strawberry producers in the state of Texas. The research so far explores producers concerns and needs when considering the initial setup of a non-traditional production system. From this, researchers are seeking to explore another means of presenting information to producers so as to extend their reach to individuals who may not be accessible through contemporary workshops or conferences.

## *Online Instruction*

Increasing educational resources that effectively convey technical knowledge is of particular necessity for producers exploring aquaponics as a means of production [2,3,7]. By evaluating the effectiveness of online instructional materials, including videos, slides, quizzes, and assessments, this research will observe how well these tools prepare learners to build an at-home aquaponics system. The goal of this project is to refine and enhance instructional design for future research and teaching, empowering all forms of learners to explore aquaponics as a viable method for food production and environmental management [4,5,7]. Effective online learning relies on

structured instructional design, multimedia integration, and interactive components. The rise of digital education platforms presents an opportunity to improve accessibility of existing aquaponics instructional materials with engagement and clarity.

The team is developing an online educational tutorial comprised of short videos for individuals to watch and observe. The tutorial videos will be done in a full production studio that can handle sound, editing, lighting, and various components for filming. Tutorials will be designed to provide students with intricate details that can be easily followed on how to build an aquaponics system. Tutorial videos will be edited to ensure they are of the upmost quality so as to showcase how learning can be enhanced when utilizing full production studio. The idea behind the video structures is to simulate a television show adding a visually appealing and entertaining component for individuals to watch.

The project is original in that it proposes the development of a comprehensive online method for teaching and guiding individuals in building at-home aquaponics systems. Through engaging and interactive online instruction, we aim to bridge knowledge gaps in aquaponics and provide practical, hands-on learning experiences that enhance understanding of sustainable food production. This project will offer valuable educational resources for students, hobbyists, and educators, helping them gain the skills and knowledge needed to successfully implement aquaponics systems in a variety of settings, supporting both personal and professional growth in this emerging field.

## Methodology

The methodology for this study focuses on developing a structured framework for designing and implementing an effective online aquaponics tutorial. The approach follows a systematic instructional design process to ensure clarity, engagement, and practical application for learners. The methodology consists of two phases: Development and Implementation; and Evaluation and Refinement.

### *Development and Implementation*

The first phase of this study involves the creation of a structured framework for developing the online aquaponics tutorial. The framework is grounded in online instructional design principles, ensuring that content is logically sequenced and pedagogically sound. This development phase of the project focuses on script writing and content ideation. For this project, the aquaponics system will be featured in instructional videos for teaching students, producers, and learners, both traditional and non-traditional, on how to build and manage similar systems at home. These videos will provide comprehensive training on aquaponics, with a focus on practical, hands-on learning through detailed instructions and examples. The aim is to help learners understand how aquaponics, a controlled environment agriculture (CEA) system, can be applied in various settings in a feasible manner. The project has long-term educational implications for agricultural engineering education showcasing that online instruction is possible through innovative tutorials and lessons. In addition, creating a functional aquaponics system is essential to ensure the videos are accurate and effective. The instructional videos, along with quizzes and assessments, will be used to measure learning outcomes. By the end of this project, two key goals will be achieved: 1)

Create an instructional video series that demonstrates the construction and operation of an aquaponics system, and 2) Assess the effectiveness of the videos in improving students' understanding of aquaponics concepts and reception of material presented.

Once the framework is established, the tutorial is developed and implemented on an accessible online learning platform. The workflow for evaluating the effectiveness of online instruction for building an at-home aquaponics system includes key steps. First, instructional materials, including videos, slides, and quizzes, will be developed during development, and then organized to guide participants through building an aquaponics system on their own time. The equipment used in these lessons will include a submersible water pump, a glass fish tank, foam board, a plastic container, pipe-to-tank seals, PVC tubing, an air pump with diffusion accessories, and additional fixtures. Second, plants and stock fish will be implemented in a secondary system built to showcase recorded changes over time. Using a quality digital recording camera will provide high-end video footage of plant and fish growth to be used in tutorial material. Third, after all footage is recorded, it will be compiled and distributed with two surveys for individuals to complete. A pre-study online survey will assess participants' initial knowledge and confidence in building a small at-home system. Once completed, participants will follow the instructional content provided. Tasks with ongoing assessments to track their progress and engagement may be implemented using online quizzes and feedback as well. Lastly, an online post-study survey and performance evaluation will be conducted to measure improvements in knowledge, skills, the ability to successfully describe how to replicate the aquaponics system, and overall perception of information presented.

A tabletop sized aquaponics system will be built, in pieces, which will accomplish several important objectives for education. Step-by-step transparency is essential in ensuring that the design can be accomplished by most learners as well as helping individuals understand the inner workings of the system. There will be no “black boxes” or information left out (as best as possible) within the time limits. Assembly will be relatively inexpensive and require minimal power to operate. However, all aquaponics require power for pumps and compressors. These items do not consume large amounts of power and should not be a hinderance to the learner. The system will be constructed and filled with water, fish, and crops all on camera in a reasonable amount of time to showcase all parts of the project. All parts of the system will be built from parts which can be found at a local hardware store or online store. The same will be done with stock fish and plants (either online or at a pet/plant store). Fish and plants will be maintained for future use in other aquaponics studies at a later date with plant and animal growth/health being recorded and monitored after the study’s duration.

The zebrafish (*Danio rerio*) has been selected for this project due to its suitability for aquaponics educational setups, attributed to its hardiness, small size, and well-documented care requirements. Their accessibility and ability to produce essential nutrients for plant growth make them an effective model for demonstrating nutrient cycling in aquaponics. Additionally, zebrafish are widely used in educational and research contexts, allowing for continuity in future projects while providing a foundational model for aquaponics and other biological systems. Approximately 20 to 40 zebrafish, depending on tank size, will be incorporated into the study within a 20-to-40-gallon freshwater aquaponics system. This stocking density aligns with aquaculture standards of one pound of fish per 10 gallons of water, ensuring optimal visibility,

sufficient nutrient production for plant growth, and manageable sample sizes for consistent data collection, all while maintaining educational and welfare standards without overcrowding.

The project aims to educate individuals on aquaponics principles and system construction through a structured online tutorial, emphasizing the symbiotic relationship between crops and fish. A second tank will house the zebrafish to illustrate how fish waste provides nutrients to plants, which, in turn, help filter and maintain water quality. This secondary system will be used strictly for observation, with no direct intervention or handling unless necessary, ensuring adherence to standard care guidelines for zebrafish health and welfare. The fish will be housed in a designated lab to maintain a controlled environment with regulated water quality, temperature, and lighting conditions essential for their biological needs and the nutrient cycling process. Continuous monitoring will ensure immediate intervention if needed, supporting consistent data collection while aligning with university and national protocols for animal care. Institutional approvals, including IRB and IACUC, have been secured prior to the study's initiation.

***Evaluation and Refinement***

The final phase of the study focuses on assessing the tutorial's effectiveness and refining the instructional approach for future use. A combination of pre- and post-assessments measures learners' knowledge acquisition and confidence in applying aquaponics concepts. Roughly 20+ students taking a variation of an Agriculture or Engineering online or in-person course in Spring 2025, will be utilized in this study. Given the small sample size of the course, nonparametric tests (e.g., Wilcoxon Signed-Rank) will be used to analyze pre- and post-survey results, comparing knowledge retention and engagement across the instructional formats. Data will help identify which instructional elements, such as video pacing, visual aids, quizzes, etc., most effectively enhance learning outcomes. The statistical workflow will be operated through an open-source ecosystem operating in the Python and R Languages and will be maintained in a private GitHub repository for further work and development in subsequent years. Videos and educational material will be maintained in a learning management platform.

Researchers expect the online instruction for building an at-home aquaponics system to yield high levels of knowledge retention and successful system construction, with minimal need for additional guidance. Instructional materials will be designed to closely replicate real-world conditions, ensuring that participants can accurately follow the steps to build and manage their own aquaponics systems at home. This is crucial as it addresses the growing demand for practical, hands-on education for CEA and innovative production systems. By evaluating the effectiveness of various instructional elements, researchers aim to provide valuable insights for educators and other researchers developing similar courses and/or lectures.

Lastly, it is anticipated that results from this study, presented at educational and agricultural conferences, will foster collaboration with a variety of institutions and open opportunities for partnerships with other Land-Grant universities. After completing this project, researchers plan to seek external funding to further develop instructional methods and expand the program, potentially recruiting graduate students to assist in refining the educational materials.

## Summary and Conclusions

A digital revolution is reshaping agricultural practices, and this project aims to fill gaps in aquaponics knowledge while establishing a hands-on research program in Agricultural Engineering at WTAMU. This initiative, one out of several, focuses on controlled environment agriculture (CEA) as a tool for producers. Through innovative online instruction, researchers aim to provide educational materials that teach individuals how to design and manage aquaponics systems, offering a unique way to explore CEA. Individuals will have the opportunity to learn aquaponics concepts and engineering principles through this new, interactive online format. They will gain practical experience in building and maintaining aquaponics systems and learn how these systems can be applied in agricultural settings beyond traditional practices. By engaging in this online learning experience, individuals will develop the skills needed to explore aquaponics as a controlled environment system for potential future use in the industry. The results from this research will be used to submit external proposals that focus on data-driven methodologies for evaluating the educational impact and effectiveness of online aquaponics instruction. Overall, this study presents a structured framework for online aquaponics education, emphasizing accessibility and engagement. Future work will refine the instructional design based on iterative feedback and learner performance data. The findings will contribute to the broader field of online education by providing insights into effective knowledge dissemination strategies for specialized topics such as aquaponics.

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