



Artículo de investigación

Survey on the use of hydroponic greenhouses in the classroom. Effects on students' eating habits

Encuesta sobre el uso de invernaderos hidropónicos en el aula. Efectos en los hábitos alimentarios de los estudiantes

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Abstract

During a research study focused on the application of the Bifocal Modelling methodology to the use of hydroponic greenhouses in schools to study plant growth and the identification of variables that contribute to plant health, a positive impact on students' eating habits was found. Following this finding, a survey was conducted to quantify the impact of this activity on students' perceptions of vegetables grown in the classroom. The results are positive and indicate that incorporating the management of a vegetables garden or hydroponic greenhouse into the curriculum can have positive effects on the eating habits of the students.

Keywords: STEM, modelling, makers, education, hydroponic greenhouse

Resumen

Durante una investigación enfocada a la aplicación de la metodología de Modelado Bifocal al uso de invernaderos hidropónicos en escuelas para estudiar el crecimiento vegetal y la identificación de variables que contribuyen a la salud de las plantas, se encontró un impacto positivo en los hábitos alimentarios de los estudiantes. Tras este hallazgo, se realizó una encuesta para cuantificar el impacto de esta actividad en las percepciones de los estudiantes sobre las verduras cultivadas en el aula. Los resultados son positivos e indican que incorporar al programa escolar el manejo de una huerta o invernadero hidropónico puede tener efectos positivos en los hábitos alimentarios de los estudiantes.

Palabras clave: STEM, modelado, movimiento “*maker*”, educación, invernadero hidropónico

Introduction

For the past four years, the National Institute for Documentation, Innovation and Educational Research (INDIRE) has been conducting several cycles of scientific research in about 30 schools of the Italian School System (Fuhrmann et al., 2021), investigating the benefits of using hydroponic greenhouses to teach science subjects, understanding the importance of modeling through the application of the Bifocal Modeling Methodology.

As reported in Ammentorp (2019), hydroponic gardening systems are a good solution to implement in schools. Hydroponics does not use soil. Plants grow in mineral-rich water, with a simple stand to hold the roots. Plants are grown mostly indoors, using sunlight or more often an LED lighting system. There are different types of hydroponic systems, each with its own pros and cons. Some people choose to build their own hydroponic gardens, or there are kits that can be purchased. The flexibility, ease, and affordability of setting up hydroponic gardens is one of its many advantages. The system very often consists of relatively inexpensive DIY (Do It Yourself) models. They are simple to use and maintain, and there is a wide variety of plants that can grow in the system year-round, including fruits, vegetables, flowers, herbs, among others. Hydroponics is also a technique that stimulates sensitivity towards ecology, since it is characterized by low water consumption; also, being an agricultural technique free of pesticides, pollutants, and heavy metals that can be found in the soil, it raises awareness on the quality of vegetables or fruits produced (Peckenpaugh, 2001).

Bifocal Modeling is an inquiry-driven science learning framework that trains students to correctly perform physical experiments, measuring variables, and creating related analogic or computer models (Blikstein et al., 2014, 2016; Fuhrmann et al., 2013, 2014, 2018). During Bifocal Modeling activities, students can observe scientific phenomena such as plant growth, heat conduction, ink diffusion through physical experimentation and design of analogic or computer models. Then they can compare the measured and simulated data gathered from these distinct empirical and virtual modalities.

The Italian School System

Referring to the Italian National Curriculum and trying as much as possible to accommodate the teachers' needs relative to their standard teaching methods, we defined a set of activities centered on the topic of plant growth in a hydroponic greenhouse correlated with mathematical modeling activities. The main theme of the research was for the kids to understand the pattern of plant growth by building a mathematical model. However, at the same time, the students learned about food quality, the presence of pesticides in the soil, and the amount of water needed to grow a plant. The literature has documented that using a hydroponic system in the classroom for educational purposes has been useful in introducing students to healthy eating habits, sustainable food systems, and community environmental issues (Carver & Wasserman, 2012).

Why investigate food-related aspects

As was previously mentioned, the main research focused on analyzing the acquisition of STEM skills while performing a science experiment and through modeling the observed phenomenon. However, as often happens, in addition to the main findings, we found evidence regarding other aspects, particularly the approach to nutrition, and we consider these "side effects" positive.

The reason of investigating the possible positive effects associated with working with plants in the classroom, stems from the hypothesis that this kind of activity can counteract problems that can be found in children as shown, for example, by the work of Traversa et al. (2017). These authors surveyed 1708 children from 6 to 11 years old and found that most of them (>75%) thought that fruits and vegetables are available all year round and are not seasonal. In addition, most students (>75%) showed difficulty in recognizing herbs by their smell. In addition, Traversa et al. (2017) argue that to prevent foodborne illnesses, it is critical to engage children in educational experiences designed to introduce them to how food is produced and to learn the correct behaviors to apply when eating fruits and vegetables.

As also Laurie et al. (2017) argued in the survey they conducted in 90 schools in South Africa, involving teachers, educators, students, garden administrators and garden workers, that activities related to growing vegetables increase students' and educators' attitudes toward vegetable and fruit consumption compared to those who do not engage in these activities. In fact, the behavior of students and educators toward growing and eating vegetables and fruits was generally positive: 68.4% of students and 86.4% of educators said they would gladly eat vegetables every day. According to educators, the specific role of actively participating in growing fruits and vegetables in nutrition education is a determining factor in learning healthy eating and nutrition (19.2%) and learning a healthy lifestyle (15.9%). Most people analyzed in the survey agreed that both vegetables (81.8% educators; 84.1% learners) and fruits (92.3% educators; 89.9% learners) taste good. Overall, 86.4% of educators and 68.6% of learners acquired the notion that it is important to eat vegetables every day, while 93.2% of educators and 84.5% of learners claimed that it is possible to eat fruit every day.

Methods

Participants and settings

A questionnaire was sent to all the 30 kindergartens and primary and secondary schools that completed the main research cycle. Teachers were chosen because they were available and willing to collaborate in the research. Seven classes, with 140 students aged 5-13 involved, accepted to have the questionnaires applied to them and answer the questions. The responding institutions included one kindergarten, four primary, and two lower secondary schools.

Design of learning materials

A DIY system was designed to facilitate the economic aspect of having a hydroponic greenhouse in the classroom, since buying a greenhouse would have been

too expensive for a school budget. To help teachers, we provided all the necessary information and materials for the successful development of the classroom experiment:

- General introduction: created to inform students and teachers about hydroponic systems.
- Lesson plan: designed to support teachers and based on the Bifocal Modeling framework.
- A manual: written for the assemblage of the DIY hydroponic greenhouse and the experiment.

The Hydroponic Greenhouse was created from recycled material following the DIY approach. It consisted of a waterproof tank with plain or nutrient-rich water. A polystyrene board with holes in it floated on the water. A plastic cup with a perforated sponge was put inside each hole to grow the plants. Daylight or a LED lamp were used as the light source.

Finally, teachers were provided with a basic mathematical digital model made with Scratch, a popular block programming system especially designed for young students (<https://scratch.mit.edu>), to begin working with students on modeling plant growth. This portion of the work will not be explored further in this article as it was the subject of the main research (Fuhrmann et al., 2021).



Figure 1. Instructional materials and manuals provided to students and teachers to build a hydroponic greenhouse in the classroom.

Instructional sequence

The time pattern of classroom activities was similar for primary and secondary schools. The activities were divided into ten weeks and four phases. The instructional materials had the same design for both levels, although teachers were free to customize them according to the academic and grade level of the students. The instructional activities were inspired by the Bifocal Modeling (Bliksten et al., 2012) approach that was the subject of the main research. The lesson plan was co-designed with the teachers and tailored to the specific needs of the class and grade level.

The activity took place in four phases, which were extensively documented and the results published by the research group (Fuhrmann et al., 2021):

1. First, students were taught what a hydroponic greenhouse is and then the class was organized into working groups of 4 or 5 students. Then a Classroom Experiment began. The groups, helped by the teacher, were asked to **build the hydroponic greenhouse** and eventually customize it. The greenhouses were

placed in a protected location, seeds were planted, and finally the day-to-day growth of the plants was observed by all groups.

2. As the plants started to grow, the students began **measuring different variables** and recording the data collected on a journal. They were also asked to observe the well-being of the plants and analyze it in terms of plant quality (healthy, sick, etc.).
3. After the observational phase of plant growth, the main research focused on the **construction and study of a paper or mathematical model** that would optimally describe plant growth according to the main variables involved.
4. The last step of the activity was to **compare the measured data with the data produced by the model** and make the necessary considerations as to whether the model appropriately described reality or whether it needed to be improved. This could be done with elementary models made from paper drawings and icons, making qualitative predictions. If, on the other hand, the model was a software, the results obtained were compared quantitatively.

As a side project, thanks to the feedback from the teachers involved, we thought it would be useful to also investigate the positive repercussions of this research on the students' perceptions of conscious cultivation, the quality of the food we eat, and the presence of harmful substances in the irrigation water.

The Questionnaire

Since we had not initially planned a methodology for observing and documenting aspects related to nutrition, we decided to re-contact all the teachers who had participated in the research and provide a short questionnaire to confirm the information observed in class. The purpose of the questionnaire was to verify whether the topic of nutrition was addressed in the classroom during the experimentation with the greenhouse and what were the students' reactions to the possibility of eating vegetables grown hydroponically.

Questions for the teachers were:

1. During the experimentation with the Hydroponic Greenhouse, did the teacher in the classroom talk about nutrition topics?
2. Was nutrition addressed because students spontaneously showed interest in the topic?
3. What themes emerged after the implementation of the hydroponic greenhouse in the classroom?
4. With the hydroponic greenhouse, have you grown an edible plant?
5. Have you eaten the cultivated plant/vegetables?
6. What reaction did you register in the students?
7. Do you think experimenting with the hydroponic greenhouse in the classroom has improved students' awareness of food-related issues?

Results

Overall, the questionnaire, responded by teachers of seven schools, provided positive indications that conducting classroom experiments involving plant growth helps students to be more sensitive to issues related to food and nutrition.

From questions 1 and 2, we realized that most of the teachers (71.4%) talked in class about food-related subjects, starting with a topic suggested by the teachers themselves. Occasionally (14.3%), students were the ones who introduced the theme. Answers to question 3 showed that having a hydroponic greenhouse in the classroom raised many ecological, economic, and social issues. The topics that were covered were numerous and are shown in Figure 2.

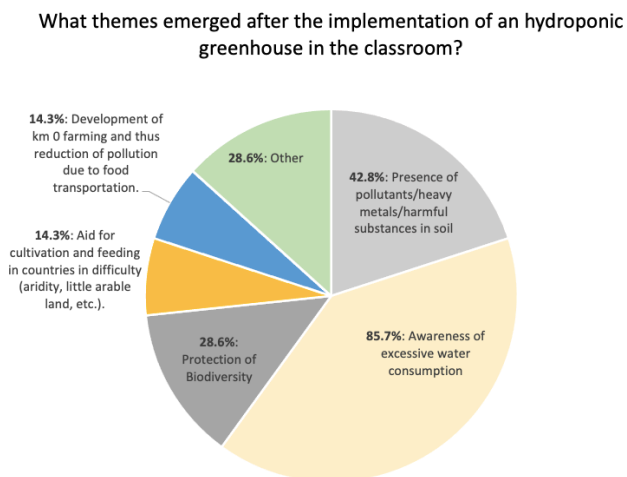


Figure 2. Themes approached in the classroom after the implementation of educational activities associated with hydroponic greenhouses.

Although we found from responses to question 4 that all but one of the schools (85.7%) grew edible plants, question 5 revealed that in no school (0%) they ate the vegetables they grew. The reason is that, as a matter of internal school rules, it is forbidden to eat anything that does not come from certified suppliers or is made by the family of the student, such as breakfast. In the comments to the questionnaire, we read that the in one school where teachers and students would have been happy to eat the salad, they had problems with the cultivation system and the plants did not reach the necessary ripeness: *“Unfortunately, the cultivated plants did not grow despite care. The students were waiting to be able to eat the salad they had grown, and with the agreement of the parents, we had already brought olive oil in the classroom to season it. However, since we could not consume the salad, we “fell back” on bread and oil. In the afternoons, around 4 p.m., we started snacking on leftover bread from the cafeteria and fruit. It was a viable alternative, as well as a pleasant habit”*. This is why question 6 was unanimously answered (100%) indicating that there was no reaction by the students.

To question 7, asking if the experimentation had improved students’ awareness on food-related issues, most teachers responded affirmatively (57.1%), whereas a lower number explicitly answered “no” (28.6%).

Conclusions

Although our main research was not centered on the impact of the hydroponic greenhouse on students’ eating habits, the results of our questionnaire report a positive effect in most cases. Teachers considered that implementing a hydroponic greenhouse in the classroom was a positive experience, since it was a good opportunity to talk about edible vegetables, sustainable

agriculture, the fight to reduce pollution, and sensitivity toward healthy food production. We consider that these types of interventions are definitely a positive first step necessary to obtain changes in children and teenager eating behaviors in the long term. A national survey carried out in 2016 in 489 schools in the United States revealed that 42% of school nutrition directors reported that students ate more fruits and vegetables after the addition of a school garden (Lloyd, 2019).

Unfortunately, more and more young children are eating a very limited variety of food (Birch & Fisher, 1998). It happens for a great many reasons, including the limited parental time available to prepare food and the availability of packaged and processed food at very cheap prices. This creates a limitation in menu variety and is associated with unhealthy habits. On the other hand, it is increasingly more common to find schools adopting hydroponic greenhouses or gardens to foster a positive attitude toward nature, ecology and respect for nature and sustainable development, as happened in a program that took place in a middle school in Brooklyn, N.Y. (Lloyd, 2019). Here the students built a hydroponic farm in a classroom and started to provide food box services to community members (i.e., they sold part of their harvest to a small number of customers at reduced prices), also contributing to raise awareness on food justice themes in underserved neighborhoods.

Our research made a small contribution in teaching students an alternative way of growing vegetables, introducing them to new kinds of food in a playful way and enticing them to taste what was produced. Unfortunately, the Covid-19 emergency greatly limited the number of schools involved in this project, since laboratory teaching was suspended, however we believe that in the future the number will grow significantly. For this reason, the research group we are working with is planning a second tranche of experiments with the greenhouse; this time the questionnaire on eating habits will be delivered along with the main questionnaire, so that the number of schools surveyed will be larger.

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