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Implementing a climate controlled smart garden system in an international interschool STEM Education Project

Pablo Flores
Nika School, Russia

Corresponding author
Ricardo Eugenio Bazan
Federal University of Rondonopolis, Brazil
bazan.ricardo@ufr.edu.br

Jofran Luiz de Oliveira
Federal University of Rondonopolis, Brazil

Edgardo Hector Manzitti
International Schools Association,Switzerland

Eylül Şen
Istanbul International School, Turkey

Prabita Makaju
Swostishree Gurukul IB World School, Nepal

Santosh Budhathoki
Swostishree Gurukul IB World School, Nepal

Introduction. The development of Climate Controlled Smart Garden Systems (CCSGS) serves as a vital educational tool in the intersection of agriculture and technology, particularly within the framework of Science, Technology, Engineering, and Mathematics (STEM) education. This project, carried out between 2023 and 2024, brought together four secondary schools from Italy, Turkey, Russia, and Nepal in a unique international collaboration effort that was backed by the International Schools Association (ISA) from Switzerland, the Federal University of Rondonópolis in Brazil, and STEM Education from Greece. The core objective was to teach students about sustainable farming practices, the environmental effects of agriculture, and how technology—like IoT and automation—can be practically applied in these settings. By engaging students in hands-on activities and fostering cross-cultural teamwork, the project sought to build their technical skills, encourage a sense of global community, and show how STEM concepts can be used to tackle real-world issues.
Keywords: Smart garden System; Greenhouse; Reducing CO2 emissions

Introduction

The application of technology in agriculture, particularly through the use of smart gardens and greenhouses, has been extensively researched. Studies highlight the benefits of integrating Internet of Things (IoT) devices, robotics, and automation in creating controlled environments that optimize plant growth and resource use. Automated systems, such as those used in smart greenhouses, allow for precise control over environmental conditions—temperature, humidity, soil moisture, and light intensity—which are critical for plant development. The literature also underscores the educational value of these technologies, noting that projects involving IoT and automation in agriculture not only enhance students' technical skills but also foster critical thinking, problem-solving, and collaboration. These projects provide a platform for experiential learning, where students can directly observe the impact of technological interventions on plant growth, thereby deepening their understanding of both scientific principles and sustainable practices.

Methodology

The methodology employed in the CCSGS project adhered to a multi-phase approach, incorporating both qualitative and quantitative methods to ensure a comprehensive understanding of the project's impact on student learning and technological integration.

The project began in June 2023 with the initial drafting and approval of the project plan, followed by the creation of communication channels among participating schools and supporting organizations. Schools from Italy, Turkey, Russia, and Nepal were selected based on their interest in STEM education and their capability to implement the required technological systems. The coordination process was managed through regular online meetings and messaging platforms, such as WhatsApp and Discord, which facilitated real-time collaboration across different time zones.

Hence, two teams of students were created in each school. They were labeled Eco and IT teams. The IT teams were responsible for setting up the hardware and managing the greenhouse's automated systems, while the ECO teams focused on plant care and monitoring.Teachers specializing in biology and information technology or robotics were appointed as project leaders in each school. They were responsible for selecting and preparing teams of students who would participate in the project.

Each school constructed its greenhouse according to their own possibilities. There were no specific guidelines as its constructionand functionality was left to the creativity of the students. It was recommended to include sensors for monitoring soil moisture, temperature, humidity, and light intensity. All participating schools received seeds from the same Italian manufacturer to ensure consistency in plant species, and the sowing took place simultaneously on November 30, 2023, at a prearranged time, coordinated via a live broadcast on Discord.

Once the greenhouses were operational, the schools engaged in continuous data collection, focusing on the environmental conditions within the greenhouses and the growth metrics of the tomato plants. Data was collected using sensors, which provided real-time monitoring of key variables. Regular meetings were held between schools to discuss findings, troubleshoot issues, and showcase their developments.

Throughout the project, STEM Education and the University of Rondonopolis provided lectures to address technical challenges and enhance students' understanding of the scientific principles underpinning the project. These educational interventions were designed to align with the hands-on activities, thereby reinforcing the theoretical knowledge with practical application. Topics covered included the relationship between environmental factors and plant growth, the principles of IoT and automation in agriculture, and sustainable farming practices.

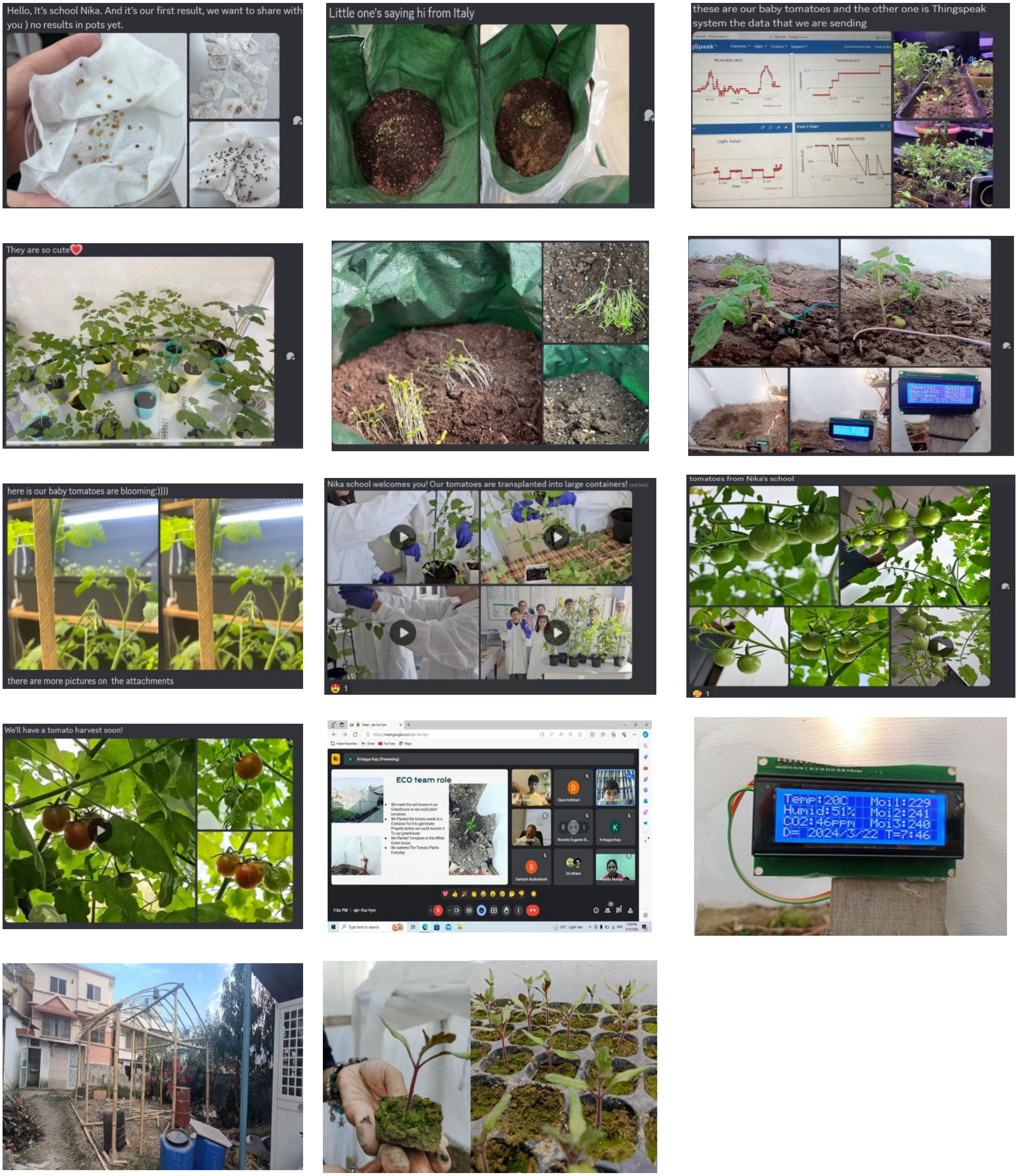
Results and Discussion

The CCSGS project integrated advanced technological tools with agricultural education, providing students with a unique learning experience that bridged theoretical knowledge and practical application.

At certain degrees, the automated systems performed reliably across the participating schools, with minor variations in environmental conditions due to geographical differences. The data collected indicated that precise control of humidity, temperature, and soil moisture significantly impacted plant growth, as evidenced by the consistent development of the tomato plants across different regions. The real-time data monitoring allowed students to observe the effects of environmental changes on plant health and growth, enhancing their understanding of the complex interactions between technology and biology.

Accordingly, Students developed a broad range of skills, including technical expertise in electronics, programming, and data analysis, as well as research skills through the systematic collection and interpretation of data. The project also fostered intercultural communication, as students and teachers from different countries collaborated closely, overcoming language barriers and time zone differences. This aspect of the project was particularly valuable, as it not only enhanced students' teamwork and communication skills but also broadened their global perspective and appreciation for diverse cultures.

Figure 1. Project Pictures



However, several challenges emerged during the project, particularly related to hardware and software integration, environmental control, and communication. For instance, one school had to substitute the microsystem with Arduino due to import restrictions. Despite these challenges, the schools demonstrated resilience and adaptability, often finding creative solutions to overcome obstacles. The collaborative nature of the project ensured that lessons learned in one location could be shared and applied elsewhere, creating a dynamic learning environment.

Thus, the project highlighted the potential for integrating technology into agricultural education, suggesting that similar initiatives could be expanded to include more schools and more diverse agricultural environments. The use of real-time data monitoring and automation in educational settings not only enhances students' learning but also prepares them for future careers in STEM fields, where such technologies are increasingly relevant.

Conclusions

The CCSGS project represents a successful integration of STEM education with practical applications in agriculture, achieved through international collaboration and the use of advanced technology. The project not only provided students with valuable technical skills and a deeper understanding of sustainable agricultural practices but also promoted cross-cultural exchange and teamwork. The challenges faced during the project, such as technical difficulties and communication barriers, were effectively managed through collaborative problem-solving, demonstrating the resilience and creativity of the participants.

In conclusion, the CCSGS project serves as a model for future educational initiatives that seek to combine technology with environmental sustainability. The lessons learned from this project could inform the development of similar programs, potentially involving a broader range of schools and exploring additional technological innovations, such as artificial intelligence and machine learning, to further enhance the educational experience and the efficiency of agricultural systems.

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