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Environmental Education

Greenhouses and vermicomposting: a facilitator of the teaching and learning process

Estufas e vermicompostagem: um facilitador do processo de ensino e aprendizagem

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ABSTRACT

The integration between curricular components and an educational artifact—a vegetable greenhouse with vermicomposting—aims to enhance the teaching-learning process and foster interdisciplinarity in school education. Using the Design Science Research (DSR) method, routines were identified for various courses, such as Agronomy, Chemistry, and Tourism Management Technology, by linking the curriculum content to the elements of the greenhouse. The study was conducted at an educational institution, where the curricular components of multiple courses were mapped, and their potential connections with the proposed artifact were analyzed. As a result, 23 routines were identified for the Agronomy course, 2 for Systems Analysis and Development, 3 for Chemistry, 2 for Tourism Management Technology, 5 for Biological Sciences, 6 for the Integrated High School Agricultural Technician course, 1 for the Integrated High School Computer Technician course, and 5 for the Integrated High School Food Technician course. This approach proposes a practical teaching method, as it allows students to gain direct experience with the concepts learned in the classroom. This strategy not only promotes a deeper understanding of the content but also prepares students to tackle complex challenges in the labor market by encouraging a more holistic and interdisciplinary education. The study highlights the importance of seeking educational benefits through the integration of teaching, research, and outreach, enabling the advancement of practical knowledge in a specific field of study.

Keywords: Environmental Technology; Vermicomposting; Educational Benefits

RESUMO

A integração entre componentes curriculares e um artefato educacional, uma estufa de hortaliças com vermicompostagem, visa melhorar o processo de ensino-aprendizagem e fomentar a interdisciplinaridade na educação escolar. Com uso do método Design Science Research (DSR), foram identificadas rotinas para diferentes cursos, como Agronomia, Química e Tecnologia em Gestão de Turismo, ao relacionar o conteúdo programático com os elementos da estufa. O estudo foi conduzido em uma instituição de ensino, onde foram mapeados os componentes curriculares de diversos cursos e suas possíveis conexões com o artefato proposto. Como resultado, foram identificadas 23 rotinas para o curso de Agronomia, 2 para Análise e Desenvolvimento de Sistemas, 3 para Química, 2 para Tecnologia em Gestão de Turismo, 5 para Ciências Biológicas, 6 para o Técnico em Agropecuária Integrado ao Ensino Médio, 1 para o Técnico em Informática Integrado ao Ensino Médio e 5 para o Técnico em Alimentos Integrado ao Ensino Médio. Essa abordagem propõe uma forma prática de ensino, pois possibilita aos alunos uma experiência direta com os conceitos aprendidos em sala de aula. Essa estratégia não só promove a compreensão dos conteúdos, mas também prepara os estudantes para enfrentar desafios complexos no mercado de trabalho, ao estimular uma formação mais holística e interdisciplinar. O estudo destaca a importância de buscar benefícios educacionais através da integração entre ensino, pesquisa e extensão, ao possibilitar o avanço do conhecimento prático em um determinado campo de estudo.

Palavras-chave: Tecnologia Ambiental; Vermicompostagem; Benefícios Educacionais

1 INTRODUCTION

Integrating novel educational approaches aimed at increasing student learning experiences is a vital task in current education. One such strategy that is gaining steam is the use of experiential learning environments, which are intended to go beyond typical classroom boundaries and immerse students in hands-on teaching experiences. The conceptualization and execution of educational artifacts that capture real-world phenomena and principles within an educational framework are central to this paradigm.

The vegetable greenhouse is at the vanguard of educational innovation, serving as an interdisciplinary hub for agriculture, environmental technology, vermicomposting, and hydroponics. The vegetable greenhouse is more than simply a physical structure; it represents an educational ecosystem in which students interact with living systems, ecological processes, and sustainable practices in concrete ways.

Moreover, the educational benefits inherent in the integration of these practices within the curriculum are manifold. By engaging in activities such as composting, seed germination, and crop cultivation within the confines of the vegetable greenhouse, students not only acquire practical skills but also develop a deeper understanding of ecological principles, sustainable agriculture, and environmental stewardship.

Furthermore, the interdisciplinary nature of the vegetable greenhouse fosters collaboration across academic disciplines, encouraging students to draw connections between diverse fields of study and cultivate holistic perspectives on complex societal challenges.

Educational Institutions (IE), with their diverse curricular components scattered throughout multiple courses, have the potential to build interdisciplinary mechanisms capable of integrating the community and improving the teaching-learning process. According to Morgado and Santos (2008), a vegetable garden can be used to promote environmental education.

Environmental education, according to Brazil (1999), is the process of incorporating ecology-related knowledge, skills, attitudes, and social values into educational institutions on a long-term basis. Projects that used vegetable production to practice environmental education were reported on by Calgaro et al. (2013), Freitas et al. (2013), and Duarte Junior et al. (2014), while Alcântara et al. (2016) confirmed a compost bin as a solution for the school's organic waste.

By building a compost bin with the help of students from the school and assessing their understanding of waste disposal, Trentin, Reffatti, and Sereia (2021) were able to put this approach into effect. In order to generate fertilizer for a vegetable garden, Lima and Teixeira (2017) employed a worm compost bin. They also encouraged student visits and used a questionnaire to assess the educational potential. The findings demonstrated that people were aware of the ideas behind vermicomposting and environmental education. Consequently, it is intended that the artifact put forth here would produce these outcomes.

Boeira (2019), Silva et al. (2020), and Eloy et al. (2019) used the compost bin and vegetable garden with worms fed on leftover food scraps. In order to integrate curriculum elements with a scientific experiment, Caeiro (2017) integrated vegetables with this procedure and compared factors in the biofertilizer produced. Here, the main goal was to propose an artifact—a vegetable greenhouse with vermicomposting—that would enable the integration of teaching, research, and extension. This involved identifying the necessary materials and creating procedures to make composting with earthworms possible, as well as producing vegetables, biofertilizer, and conducting scientific experiments in educational institutions.

Santos et al. (2019) took an interdisciplinary approach to vermicomposting in a school context with vegetable production. In a convergent way, but inside a greenhouse and at an earlier stage, because here an artifact was proposed as a prescribed change, inspired by Santos et al. (2018), by being similar in interdisciplinarity when involving composting with worms fed with pieces of vegetables and fruits in an educational institution through an artifact, from the perspective of Design Science Research.

This was justified by Vacari et al. (2020) who reflected on the lack of relevant publications on teaching scripts. This gap represented a search for routines for visits by classes from the school itself to the artifact (greenhouse), when the content of the curricular component related to some item of this greenhouse. This study targets high school students enrolled in technical courses (such as Agriculture, Informatics, and Food Technology) and undergraduate students in Agronomy, Chemistry, and Tourism Management Technology, aiming to integrate curriculum components with the proposed educational artifact

Given this possibility, the following research question arose: how can we design routines for visits to a vegetable greenhouse with vermicomposting within an educational institution? It is hoped that this artifact will provide educational benefits by fostering interdisciplinarity between curricular components and making it possible to carry out research with the preparation of final course papers that address some of the artifact's processes.

2 MATERIALS, METHODS, RESULTS AND DISCUSSION

Identifying how to design routines for visits to a vegetable greenhouse with vermicomposting within an educational institution was the objective of this study. It means looking for relationships between curricular components and items in the artifact, to make it possible to visualize class visits according to the related content, to observe in practice certain concepts contained in the curricular components.

This objective was achieved by using the Design Science Research method used in Dickie (2010), Barreto and Schmid (2017), Almeida (2018), Farinon (2020), Spanaki et al. (2022), Nyakuri (2022) and Santos et al. (2018). This research was carried out according to the principles of the Design Science Research (DSR) methodology. Hevner et al. (2004) state that DSR can be appropriate when thinking about artefacts to solve organizational challenges in specific domains.

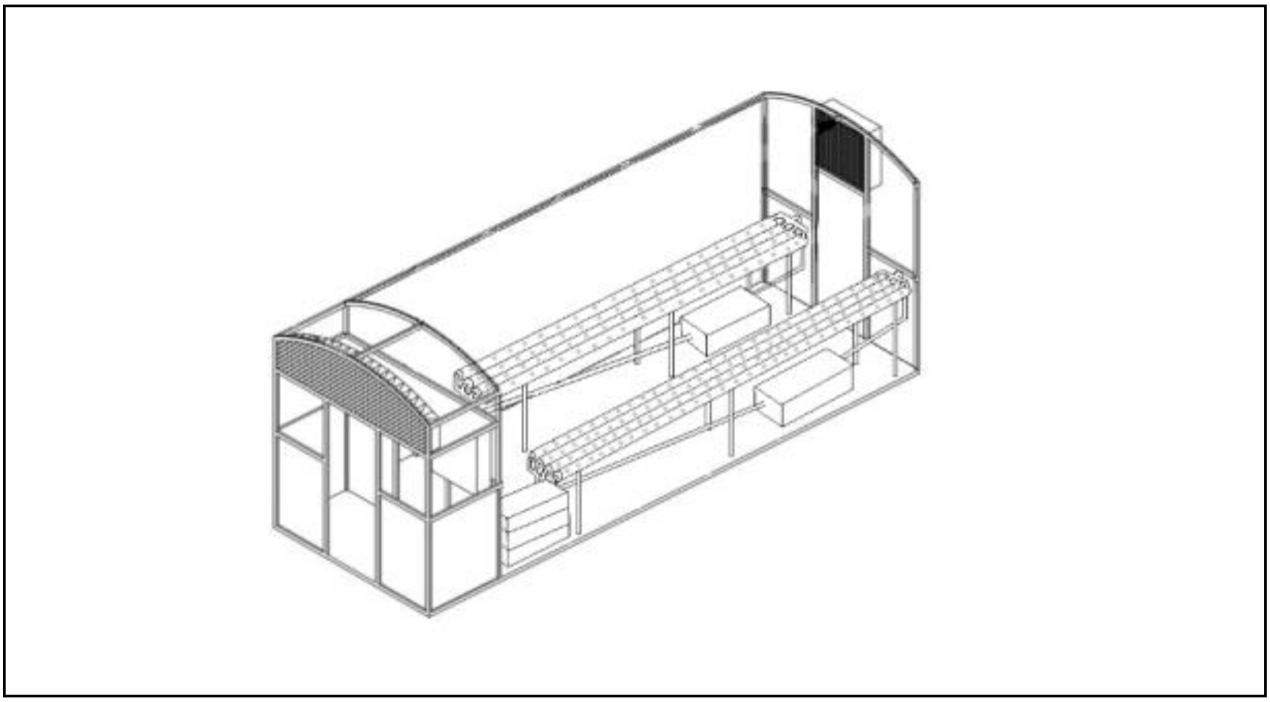
RSD seeks to create new or better ways of behaving in the world in order to alter and improve reality (Baskerville et al., 2018). Hevner et al. (2004) explain that the process of creating and using an artifact conveys knowledge and understanding of a design problem and its resolution. In addition, reliable and valuable research can contribute to the corpus of knowledge in a given topic and field (Dresch et al., 2015).

The idea of creating objects to alter and improve the world is common, often in a prescriptive way, according to Myers and Venable (2014), who contrast this with the tradition of the natural and social sciences, which aim to understand phenomena in the real world. In a similar vein, Simon (1982) defines it as a process that involves developing a series of steps to transform current circumstances into the desired reality.

2.1 Materials and methods

The artifact of this manuscript comprised a 16.80m^2 greenhouse with vermicomposting, as shown in the figure below:

Figure 1 – Sketch of the greenhouse with the vermicomposting components



Source: Vitor Matheus Presciliano (2023)

According to this figure, the artifact has a part for hydroponic cultivation of vegetables and two spaces at the entrance for compost bins with worms. Another material used was the curricular components of an educational institution, as shown in the table below:

According to this table, the curricular components for each course were related to the items in the greenhouse shown as an artifact in figure 1. The Content Analysis technique was used on the artifact and teaching plans of a particular educational institution. It is hoped that a vegetable greenhouse with vermicomposting will generate educational benefits by mapping out how this artifact can relate to the curricular components of the courses at the educational institution.

Tabela 1 – relates curricular components to the artifact

Course	Number of with adherence
Agronomia	23
Análise e Desenvolvimento de Sistemas	2
Química	3
Tecnologia em Gestão de Turismo	2
Ciências Biológicas	5
Técnico em Agropecuária Integrado ao Ensino Médio	6
Técnico em Informática Integrado ao Ensino Médio	1
Técnico em Alimentos Integrado ao Ensino Médio	5

Source: Vitor Matheus Presciliano (2023)

2.2 Results

Chart 1 – Relationship between Agronomy and Artifact

SEMESTER	CURRICULAR COMPONENT	PROGRAM CONTENT
1	Introdução à Agronomia	Os principais modelos tecnológicos utilizados na agropecuária

Source: Vitor Matheus Presciliano (2023

For the Agronomy course, the curricular component “Introduction to Agronomy” was selected, in which the syllabus includes the presentation of technological models applied to agriculture. In this context, a visit to the greenhouse is seen as an opportunity to see these technological models in practice.

Chart 2 – Relationship between ADS and Artifact

SEMESTER	CURRICULAR COMPONENT	PROGRAM CONTENT
2	Gestão de Projetos	Gerenciamento de integração

Source: Vitor Matheus Presciliano (2023)

For the Technology in Systems Analysis and Development course, the “Project Management” curriculum component was chosen. Within its syllabus, students will have the opportunity to recognize project management techniques and identify the means to apply them effectively.

Chart 3 – Relationship between Química and Artifact

SEMESTER	CURRICULAR COMPONENT	PROGRAM CONTENT
5	Química Ambiental	Princípios da Química Verde

Source: Vitor Matheus Presciliano (2023)

For the Chemistry course, the “Environmental Chemistry” curriculum component was selected, whose syllabus addresses the application of methods to demonstrate a set of principles aimed at reducing or eliminating the use or generation of hazardous substances during the planning, manufacture and application of chemical products.

Chart 4 – Relationship between TGT and Artifact

SEMESTER	CURRICULAR COMPONENT	PROGRAM CONTENT
2	Tecnologia em Gestão de Turismo	Conceitos: ecossistema, habitat, nicho ecológico, comunidade clímax

Source: Vitor Matheus Presciliano (2023)

For the Technology in Tourism Management course, the curriculum component “Technology in Tourism Management” was selected. Its syllabus will cover concepts related to ecology, non-polluting means of transport and the creation of an environment conducive to cultural and local preservation, thus promoting a favorable climate for sustainable tourism.

Chart 5 – Relationship between CB and Artifact

SEMESTER	CURRICULAR COMPONENT	PROGRAM CONTENT
4	Morfologia e Anatomia Vegetal	Equipamentos ópticos; Origem, organização e hábito das plantas

Source: Vitor Matheus Presciliano (2023)

For the Biological Sciences course, the curriculum component "Plant Morphology and Anatomy" was selected, in which students will study the structure and shape of plants, with an emphasis on observing the morphology of the crop grown in the greenhouse.Table 3 – AECs and Surface Runoff Coefficients for each land use in UPG-P4Source: Adapted from (ANA, 2018)

Chart 6 – Relationship between TCIEM and Artifact

YEAR	CURRICULAR COMPONENT	PROGRAM CONTENT
1	Produção Vegetal - Solos e Olericultura	Sistemas de plantio

Source: Vitor Matheus Presciliano (2023)

For the Integrated Agricultural Technician course, the curriculum component "Plant Production - Soils and Olericulture" was selected. Within its syllabus, planting systems will be covered, including olericulture, with the possibility of visiting a greenhouse, which represents a protected planting system, providing students with practical experience in this context.

Chart 7 – Relationship between TAIEM and Artifact

YEAR	CURRICULAR COMPONENT	PROGRAM CONTENT
2	Química de Alimentos	Água: Atividade de água em alimentos. Importância das isotermas de sorção. Solubilidade de constituintes dos alimentos em água

Source: Vitor Matheus Presciliano (2023)

For the Integrated High School Food Technician course, the “Food Chemistry” curriculum component was selected. Its syllabus will cover the importance of water in food production and preservation. This will enable a visit to the greenhouse, with a special focus on the Nutrient Film Technique (NFT) system, in which water is a central element for the growth and nutrition of the plants contained in the greenhouse.

Chart 8 – Relationship between TIIEM and Artifact

YEAR	CURRICULAR COMPONENT	PROGRAM CONTENT
1	Algoritmo e Programação	Conceitos sobre algoritmos

Source: Vitor Matheus Presciliano (2023)

For the Integrated High School Computer Technician course, the “Algorithm and Programming” curriculum component was selected. Within its syllabus, students will learn to create algorithms to control variables in specific environments. These algorithms can be applied, for example, to controlling the climate in an environment. In this context, the use of the greenhouse can be explored as a practical application of these algorithms, contributing to the development of technological solutions aimed at environmental control.

Based on these adherence and scripting results, it was possible to visualize routines for scripting student visits to the educational institution’s courses for certain curricular components. That is, when teaching content related to a class visit to the artifact.

For the Agronomy degree course, the curricular component Introduction to Agronomy was selected. This subject covers topics such as technology in agriculture, so with the artifact being an agricultural and technological medium, students can learn about how it works, such as the NFT irrigation system, lettuce seeds and how vermicomposting works.

The curricular component Project Management was selected for the Technology in Systems Analysis and Development degree course. In it, students will use the artifact to develop ways of creating, managing and integrating projects and processes and the activities needed to identify, define, combine, unify and coordinate the various management processes and activities.

For the Chemistry degree course, the Environmental Chemistry curriculum component was selected. Where it brings the importance and awareness of the care of handling chemical products, so the artifact brings a complement with its systems implemented in the greenhouse, such as the NTF system that uses chemical substances in its composition.

For the degree course in Tourism Management Technology, the curriculum component Tourism Management Technology was selected. Where students will be taught ecological concepts and non-polluting means for a favorable climate for the creation of a culture, so with the artifact at their disposal they will show other methods for the creation and development of a culture through a controlled climate and environment.

For the higher education course in Biological Sciences, the curriculum component was Plant Morphology and Anatomy. Through the artifact, the student will be able to teach about the morphology of hydroponic culture.

For the Technical Course in Agriculture Integrated into High School, the curriculum component was Vegetable Production - Soils and Olericulture. In this way, students will understand planting systems, the six main systems and how they work, so the artifact with its NFT planting system enables practical learning about how the system works.

For the Integrated High School Food Technician course, the Food Chemistry curriculum component offers students the opportunity to understand the importance of water and other chemical components in growing a hydroponic crop. They learn how hydroponic growing systems work and the benefits of using them.

In the Computer Science Integrated High School Technical course, the Algorithm and Programming curriculum component enables students to create algorithms to control the climate of an environment. However, when analyzing the operation of the greenhouse and its systems, it can be seen that access to the programming codes for the irrigation system may not be available. In this sense, students can apply their learning through automation prototypes, such as Raspberry Pi or Arduino.

For the Technology in Systems Analysis and Development degree course, the Project Management curricular component allows students to develop the skills to create, manage and integrate projects and processes. However, when examining the systems implemented in the greenhouse, it is clear that it may be necessary to use automation prototypes, such as Raspberry Pi or Arduino, to get around the possible lack of access to the programming codes for the greenhouse systems.

2.3 Discussion

The teaching-learning process can use the DSR research method to design ways in which a given artifact can relate to curricular components and generate educational benefits. Based on the Pedagogical Course Project (PPC) of the Federal Institute of São Paulo - Campus Barretos and considering the syllabus and program content of each course, it is possible to identify points where teachers of the selected curricular components would have the opportunity to visit the greenhouse.

For the Integrated High School Food Technician course, the “Food Chemistry” curriculum component covers topics that are relevant to understanding the importance of water and other chemical components in the cultivation of hydroponic crops. In this context, a visit to the greenhouse could be carried out during the study of these topics, providing students with a practical experience related to the content covered in class.

In the Computer Science Integrated High School course, the "Algorithm and Programming" curriculum component offers students the opportunity to develop algorithms to control the climate in an environment. Considering the possible application of these algorithms in the context of the greenhouse, students could visit the greenhouse to better understand how the automation systems used in environmental control work.

In the Technology in Systems Analysis and Development course, the "Project Management" curriculum component prepares students to create, manage and integrate projects and processes. A visit to the greenhouse could be integrated into the study of this curricular component, allowing students to understand how the principles of project management are applied in practice, especially in contexts related to the automation and technology used in the greenhouse.

By integrating visits to the greenhouse with the selected curricular components, the aim is to promote interdisciplinarity between the different fields of knowledge, as highlighted by Noguera (2011). This approach gives students a broader and more integrated view of knowledge, contributing to a more holistic education and preparing them to face complex challenges in the job market.

3 CONCLUSIONS

In conclusion, integrating educational institutions with interdisciplinary mechanisms such as vegetable gardens and composting bins has enormous potential for improving the teaching-learning process and increasing community participation. According to several research and projects, introducing environmental education into curricula through practical applications such as vermicomposting and hydroponic farming not only enhances ecological awareness but also develops vital skills and values in students.

Educators can bridge the gap between theoretical knowledge and real-world applications by implementing projects such as the vegetable greenhouse with vermicomposting, which provide students with hands-on experiences that increase their grasp of complicated subjects. Furthermore, by connecting these initiatives with the many curriculum components of various courses, universities can promote interdisciplinary collaboration and enrich students' educational experiences across disciplines.

The use of Design Science Research (DSR) methodology to create and execute such artifacts emphasizes the value of practical problem-solving and innovation in educational contexts. By developing practical answers to educational difficulties, educators can not only improve learning outcomes but also give significant insights to the larger field of educational research.

Furthermore, the systematic strategy indicated in this study for developing routines for student visits to the vegetable greenhouse using vermicomposting demonstrates how institutions can effectively integrate experiential learning opportunities into current curricula. Educators can optimize the educational benefits of such programs by properly connecting these visits with specific course objectives and program material.

Finally, efforts such as the vegetable greenhouse with vermicomposting provide a comprehensive approach to teaching by encouraging students to practice environmental stewardship, critical thinking, and multidisciplinary teamwork. As educational institutions continue to experiment with novel teaching approaches, incorporating practical, hands-on experiences like those provided by these projects will be critical in preparing students for the problems of tomorrow.

Based on these adherence and script results, it was possible to visualize routines for taking students from IFSP-Barretos courses to certain curricular components. The idea is for the teacher to teach the related content by visiting the greenhouse with the class (artifact).

However, in search of an answer to the question "how to design routines for visits to a vegetable greenhouse with vermicomposting within an educational institution? ", the answer would be to visualize educational benefits by identifying interdisciplinarity between curricular components and enabling research with the preparation of course completion papers that address some process of the artifact, using the Design Science

Research method, used in Dickie (2010), Barreto and Schmid (2017), Almeida (2018), Farinon (2020), Spanaki et al. (2022), Nyakuri (2022).

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