Journal of Engineering Education Transformations,
Volume No. 37, January 2024 Special Issue, eISSN 2394-1707

Environmental Sustainability Project by First-Year Engineering Students: Composting

[1]Lavanya Nagamalla, [2]G Vanaja Reddy, [3]Gnanitha Suryadevara, [4]N V Rajendra Kumar
[1]Associate Professor, Hyderabad Institute of Technology and Management [2]Associate Professor, Hyderabad Institute of Technology and Management [3]UG Student, Hyderabad Institute of Technology and Management
[4]Associate Professor, Hyderabad Institute of Technology and Management
[1]lavanyan.sh@hitam.org
[2]vanaja.humanities@hitam.org
[3]ssvas229@gmail.com
[4]nvrajendrakumar.sh@hitam.org

Students in Hyderabad, India, explain the "freshmen's Composting Initiative", a project they undertook as a part of their environmental science course. The initiative puts a strong emphasis on problem-based learning (PBL) and real-world sustainability. It emphasizes the significance of giving pupils the knowledge and abilities necessary for environmental responsibility as well as the connection between human well-being and the natural world. The all-India Council for Technical Education's (AICTE) decision to include "Environmental Science" in the first-year B.Tech. Curriculum served as the impetus for the effort. Although sustainability is emphasized in policies, there is frequently a gap in actual application, which this research seeks to fill. This research helps students comprehend sustainable business practices and environmental issues while also giving them a foundation for putting sustainability into reality. It illustrates the transformative potential of PBL and the part that students play in bridging the sustainability gap between theory and practice. In conclusion, the "Freshmen's Composting Initiative" shows how first-year engineering students may actively support sustainability through practical projects, aligning with the increased emphasis on environmental educationand the real-world application of sustainable ideas.

Keywords— **Compost, environment, PBL, sustainability.**

JEET Category—Choose one: Research, Practice, or Op-Ed. (Please note, Op-Eds are by invite only. Refer to the Paper Submission and Review Guidelines for more details.)

I. INTRODUCTION

Environmental sustainability education aims at equipping people with the knowledge and skills, that deem a responsibility to care for the environment conscientiously. It seeks to prepare students with the skills they need to tackle the intricate environmental problems that society is currently confronting and to work towards a more sustainable future. It is not only in our best interests to consider the environment, but it is also morally, ethically, and practically indispensable. (Shepherd, M., & Cosgriff, M. 1998).

In order to maintain and preserve the environment for the benefit of both present and future generations, it is necessary to recognize the interdependence between human well-being and the natural world. In the pursuit of sustainable development, universities play a pivotal role (Arribas Layton, L. 2013). All India Council for Technical Education (AICTE), with commitment to environmental stewardship, has made a significant step by integrating "Environmental Science" as mandatory Non- Credit Course into the first year of all B Tech programs. This comes under "Environment Policy 2020" which is in line with the vision 2030 of the Government, (Policy document available on the AICTE website).

The Policy is designed to emphasize that technology and nature remain interdependent and Policy highlights the significance of environmental management for technological institutions and emphasizes the need for sustainable solutions to ad- dress challenges. (Kumar, A., Samadder, S. R., & De, S. (2017) The inclusion of environmental sustainability courses in academic programs has notably increased over the past ten years in numerous disciplines. These courses can teach students about sustainability in general or focus on particular issues like green building techniques, alternative transportation options and pollution avoidance techniques. (Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. 2011) It is commonly understood that sustainable development is more than simply a theoretical idea and it demands practical application in real-world situations. (Sterling, S. 2001).

This paper was submitted for review on September 15, 2023. It was accepted on November, 15, 2023.
Corresponding author: Lavanya Nagamalla Department of Chemistry, Hyderabad Institute of Technology and Management, Telangana, India.
Address: Gowdavelly village, 501401 (e-mail: vanaja.humanities@hitam.org).

There is a growing awareness of the transformative potential of project-based learning (PBL) and environmental education, especially in the context of fostering sustainability and responsible citizenship. PBL promotes a dynamic and collaborative learning environment by engaging students actively in practical learning, while receiving direction and mentorship from teachers (Seidel et al., 2011). It promotes the exchange of ideas between professors and students, which eventually boosts motivation in studying (Darling-Hammond et al., 2020). PBL, as a comprehensive approach to teaching and learning, places a high priority on getting students involved in the investigation of real-world problems, bridging the gap between theoretical understanding and practical application (Krajcik & Phyllis, 2006). Thus, PBL equips students to become active change- makers and environmental stewards.

Even while the policy places a strong emphasis on sustainability, there is still a big gap in students' involvement in actively applying sustainability principles. This gap is an indication of a larger problem in education as effective learning and practical application are often overlooked in typical classroom set- tings (Shepherd and Cosgriff, 1998).

As an initiative to address the gap, this research aims to fill thegaps by making contributions in two key areas. Among them the First and foremost is the practice of sustainability. The mandatory course called "environmental science" in the first year B.Tech. Curriculum provides students with the sense of responsibility in contributing towards environment. In turn theengineering institute provides students an opportunity to work on the real time environmental challenges in collaboration with Fruitoholic which is fruit-based industry located in Hyderabad.

The second among this is the establishment of cutting-edge teaching techniques that connect pedagogy and practice. This course uses a project-based learning (PBL) approach that emphasizes learning by doing: It is identified that there is a huge problem in handling the organic waste produced in the fruit- based industry.

Students of the first-year engineering at Hyderabad Institute of Technology and Management (HITAM) Have participated in a composting project as an environmentally sustainable project. This project is taken up as a part of environmental science course. (Tilley, D. R., & Lu, X. S. 2011). Sustainable development necessitates action "on-the-ground". However, there are very little opportunities for students to apply sustainability ideas, one such opportunity is the composting project that is led by the first-year engineering students for a fruit-based industry. Fruitoholic produces approximately 100kg of fruit waste per day in their daily business. This waste was dumped in the landfills in turn leading to pollution. HITAM has signed a memorandum of understanding (MoU) with Fruitoholic firm to address the issue and by an assurance to convert the fruit waste to compost. (UNESCO, 2014).

I. LITERATURE

Supporting literature for the present study, the two challenges which we confront are the first one is the responsibility towards environment, which is not easy to teach students as they have to own it voluntarily (Luna et al. 2015). In several areas, including environmental awareness, universities are seen as the change agents (Mochizuki and Fadeeva 2010). The so- called "third mission of the university" is the betterment of people's lives and addressing global issues, in addition to teaching and research. Universities are a key setting for investigating, testing, developing, and disseminating the crucial elements of sustainable development (Sady et al. 2019). Universities have an option of combining students' technical abilities with the subject-matter expertise, it allows students toproduce original concepts, theories, and products centered on sustainable development concerns (Luna et al. 2015).

The Second is Project-based learning (PBL) being very crucial to incorporate in the engineering education. Project based learning is an inquiry-based educational approach that involves learners in building of knowledge through the completion of important tasks and by creating useful products(Juuti et al., 2021). The most important of all these characteristics, which separates PBL from other student-centered pedagogies like problem-based learning, is the production of artefacts that resolve real-world issues (Tamim et al., 2013). Compared to direct instruction, PBL has a more favorable effect on students' academic performance (Tipton & Furmanek, 2016). Numerous studies show that the students who actively participate in educational events have higherlevels of understanding, better abilities to absorb information, and better memory retention (Baraldi, 2021). Since students must work together with their peers to find a solution to an issue, most of the projects naturally offer possibilities for a group problem-solving (Ouyang et al., 2023).

As suggested by literature, PBL is an instructional techniqueto reduce the high cognitive load on sustainability learning andto integrate it as a key element of the environmental science course to address the challenges of environmental sustainability. The ability of the students to recognise their present knowledge, to identify the gaps in their knowledge and experience, and gaining new information to bridge the gap is a crucial component of the PBL process. Applying PBL as a framework, the present paper investigates the pros and cons ofexperiential learning as well as the creation of sustainable project that supports practice-based learning.

II. METHODOLOGY

For food industries, managing solid waste presents a significant difficulty because it frequently accounts up to 30% of incoming raw materials. In the past, landfilling was the preferred method of waste disposal, but due to the changing legislation, landfill closures, and rising tipping fees are forcing reconsideration, (Epstein, E. (1997). A promising substitute is composting. Composting has a number of benefits. It can cut the volume of organic waste up to 40%, negating the need for pricey tipping fees at landfills. Additionally, it produces items with market and a possibility for profit. Pathogens and weed seeds are destroyed by the high temperatures that composting can reach (40–70°C). Ecologically, it produces nutrient-rich soil amendments that improve the environment for plant growth. (Bernal, M. P., & Alburquerque, J. A. 2009).

The natural process of composting is fueled by microscopic living things like bacteria and fungi. They decompose organic things like plants, leaves, and food waste into a nutrient-rich substance. The compost that is produced can be utilized to improve gardens and encourage plant growth. While there are many different composting techniques, they all share a set of conditions that microbes need in order to survive and grow. (DeVellis, R. F. 2016). There are numerous composting techniques that have been successfully established, but no matter the technique, extremely certain conditions must be fulfilled for the microbes to survive and proliferate.

Faculty teaching Environmental science course for the first-year engineering students have given the theoretical knowledge on composting which includes description, procedure and need of the composting. (Seidel T, Stürmer, K., Blomberg, G, Kobarg, M, & Schwindt, K. 2011). These students have to apply the theoretical knowledge of composting that they had taken up as a project to carry this process in the HITAM campus as a part of the environmental sustainability solution for this fruit-based industry.

Students are taken to the industry to understand the problem. Students have collected the fruit waste from the industry after initial raw material preparation. Figure 1 provides the stepwise process of composting.

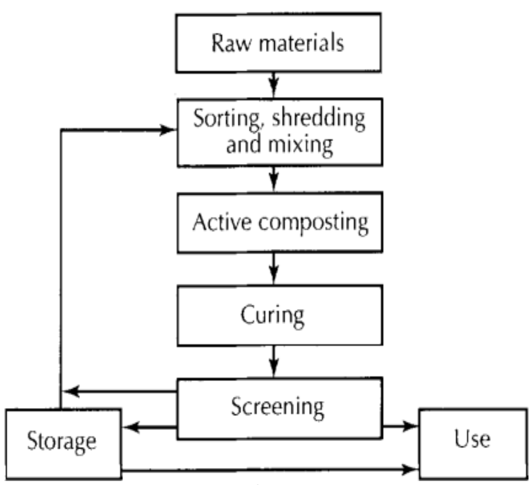

Figure 1: Flow diagram of composting process


Figure 3: Composting of week 3

The composting material is arranged in 3 piles in the wooden bins constructed in the HITAM college grounds, See the table 1 for the pile composition. Leaves (dry and wet) used in the pile 1 and pile 3 are collected from HITAM college campus, utilizing the collected leaves of campus, it closes the loop on the campus ecosystem.

It was anticipated that the composting process would be complete in eight weeks after the first rotation, for another two weeks compost is allowed to cure. To involve the large number of students, and to eliminate the prolongation of project time, four runs were carried simultaneously. Mixing or turningof the composting pile is at regular intervals is required to maintain the condition of temperature and moisture of thepiles. Table 2 provides the mixing intervals. Regular sampling was done during the different phases of composting to aid in the interpretation of results. Nutrient value, with regards to Nitrogen, Phosphorous, and Potassium (NPK) were measured which are very important parameters for the compost that enhance the plant growth., the results of NPK for the final compost are given in table 3 indicated the final compost produced is rich in nutrients (Hargreaves, J. C., Adl, M. S., & Warman,P. R. 2008). Figure 2,3, and 4 shows the different stages of thecomposting.


Figure 2: Raw material Preparation


Figure 4: Final compost After week 12

Table 1: The composition of composting layers

Pile No.	Pile Composition
Pile-1 (Botom)	70 wt.% of Mixed fruit waste + 30 wt.% green leaves (collected from college campus)
Pile-2 (Middle)	Saw dust
Pile3 (Top)	100 wt.% of dry leaves (dry leaves collected from college campus)

Table 2: Frequency of composting parameters analysis in the laboratory

Shedule	Frequency of Mixing/Week
Week 1	3 to 4
Week 2	2 to 3
Week 3	2
Week 4 to 6	1
Week 7 to 10	1 per two weeks
Week 11 to 12	Curing

Table 3: NPK Analysis of final compost

Parameter	R1	R2	R3	R4
Total TKN (Kjeldahls N %)	3.01	1.82	1.77	1.83
Total P (%)	1.75	2.01	2.07	1.72
Total K (%)	1.81	1.95	2.51	1.44

Before the project initiation, data was collected for demographic section with questions about students' personal back- ground characteristics such as gender, age, and composting knowledge. (Dillman, D. A., Smyth, J. D., & Christian, L. M. 2014). After the completion of the project, further data was collected in the form of questionnaire, the instrument aligns with the four constructs they are composting knowledge, composting practices, environmental attitudes, environmental responsibility. The author developed 20 interdependent parameters for the four constructs to develop the freshman students understanding on the students' knowledge on the conducted project and their opinion on the environment protection.

Response options for all constructs were arranged on a five-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree), and are detailed in Table 6 along with the intended items of the construct.

Data collection:

Data was collected from the freshman students after the completion of the project to assess the students' knowledge on the project and their perception on the environment protection. By asking three prospective respondents to assess the surveys' questions and offer their input on their wording and phrasing, the evidence supporting the survey instrument's apparent reliability was gathered. 134 students in total replied to the survey, Participants who didn't respond to at least 50% of the questions and who selected the same option for all the questions were excluded using group mean substitution methos. Finally, 108 participants were considered in the final dataset (Babbie, E. R. 2016).

Results

Table 4 provides the demographic analysis of the participants. It is evident that there is a significant difference in the knowledge of composting between male and female students, female students exhibited to have better knowledge, where the male students must receive extra attention from the professors directing the students. The analysis on the constructs is done using descriptive statistical (DS) method using Standard Error of Mean (SEM) and Standard Deviation (SD). (Mohini P Barde, 2012). The final results of all the constructs are shown in the Table 5. (Mohini P Barde 2012).

The agreement of each construct with the individual parameters is shown in Table 7. Median scores closely align with the means, suggesting relatively symmetrical data distributions Overall results of all the constructs show promising results with 70.9% showing excellent, 20.3% showing good and 8.7% of the students showing poor performance (Figure 5).

Table 4: Demographic parameters of sample data

S No	Category	N	%
	Total	108	100
1	Gender		
	Male	63	58.3
	Female	45	41.6
2	Engineering Discipline		
	AI ML	30	27.7
	IOT	28	25.9
	DS	25	23.1
	CS	25	23,1
3	Age		
	15-20	76	70.3
	20-30	32	29.6
4	Composting knowledge		
	High	34	31.5
	Low	74	68.5

Construct	Definition of construct	Items
composting knowledge	This construct measures the level of knowledge individuals have about composting techniques, processes, and principles.	1. I know how to create a balanced compost pile. 2. I can explain the importance of all the components in the composting procedure. 3. I understand the importance of the carbon-to-nitrogen ratio in composting. 4. I can explain composting parameters-Moisture, p^H and temperature. 5. I am familiar with the benefits of composting for soil health and waste reduction.
composting practices	This construct assesses the extent to which individuals engage in effective compost-ing practices.	1. I actively prepare the raw material by segregating, chopping and mixing. 2. I turn or mix my compost pile regularly to promote decomposition. 3. I maintain the proper moisture level in my compost pile. 4. I can take the control on the parameters during the composting 5. I can understand the completion of process and formation of finish product.
environmental attitudes	This construct reflects indi-viduals' attitudes and beliefs about the environmental benefits of composting.	1. Composting is a way for me to reduce the carbon footprint. 2. I believe composting helps divert organic waste from landfills. 3. Composting contributes to healthier and more sustainable farming. 4. I feel a sense of responsibility to compost as a way to protect the environment. 5. Composting aligns with my values of environmental conservation.
environmental responsibility	This construct measures individuals' confidence in their ability to successfully compost.	1. I feel confident in my ability to create and maintain a compost pile. 2. I believe I can troubleshoot common composting challenges. 3. I am comfortable adjusting the composting process based on changing conditions. 4. I have the skills to address odour or pest issues in my compost pile. 5. I can train fellow friends the process of composting

Table 6: Overview of the constructs within the survey instrument

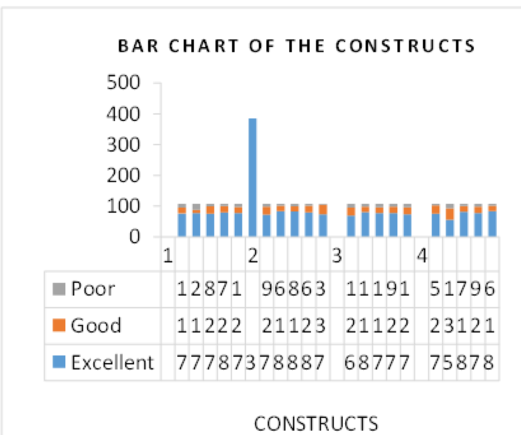

Figure 5: Representation of % of results of survey instrument

Table 7: Descriptive Statistics (DS) of results of four constructs

S No.	Statistical Parameter	Construct 1	Construct 2	Construct 3	Construct 4
1	Mean	36.6	39.3	36.1	34.9
2	Standard Error	0.8	1.5	1.4	4.9
3	Median	36.3	39.9	36.3	38.6
4	Standard Deviation	1.7	3.0	2.7	9.8
5	Sample Variance	2.7	9.1	7.4	96.7
6	Range	3.9	6.8	6.6	21.5
7	Confidence Level (95.0%)	2.6	4.8	4.3	15.6

IV. CONCLUSION

This research has not only given the students a framework for implementing sustainability, it has also influenced the students with the sustainable business practices of environmental protection and environment challenges. Sustainability and problem-based learning are two new academic fields that need attention for creative thinking. (Wals, A. E. J., & Jickling, B. 2002). Students in this research got the chance to investigate sustainability through problem-based learning, which in turn provided a dynamic and engaging platform for learning and solving the real-world problems. Additionally, by using problem-based learning as a framework for the implementation of sustainability, students were given an opportunity to engage in initiatives that benefitted the campus community, effectively bridging the knowledge gap between academia and practice.

V. FUTURE WORK

Future work on this curriculum and methodology might focus on number of areas that would enhance sustainability education and problem-based learning in a university setting. (Keeling, R. P., & Hersh, R. H. (Eds.) 2017), (Savery, J. R., & Duffy, T. M. 1995) In future, institute can participate in sustainability projects with local groups and organizations to rein- force relationships with the neighborhood. Establish collabo- rations with business, governmental organizations, and NGOs to raise money for sustainability-related projects and research. This can give funding for bigger, and for more significant projects. Utilize project-based learning to continuously evaluate the success of the course and to collect opinions from the students, instructors, and for stakeholders. Can utilize this input to enhance and modify the curriculum and PBL-based teaching strategies. The course can develop and adapt to meet the evolving needs and challenges of sustainability education and project-based learning by concentrating on these future areas, making it an even more valuable resource for students and the larger community.

VI. REFERENCES

All India Council for Technical Education (AICTE). (2020). Environment Policy 2020. [Policy document available on the AICTE website].

Baraldi, S. (2021). Active participation in educational events and its impact on learning outcomes. Educational Psychology, 41(2), 228-245.

Babbie, E. R. (2016). Survey research methods (6th ed.). Cengage Learning.

Bernal, M. P., & Alburquerque, J. A. (2009). Composting of agricultural and other wastes for production of useful organic matter: A review. Bioresource Technology, 100(18), 5485-5491.

DeVellis, R. F. (2016). Scale development: Theory and applications (4th ed.). SAGE Publications.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method (4th ed.). John Wiley & Sons.

Epstein, E. (1997). The Science of Composting. CRC Press. Haug, R. T. (1993). The Practical Handbook of Compost Engineering. CRC Press.

Hargreaves, J. C., Adl, M. S., & Warman, P. R. (2008). A review of the use of composted municipal solid waste in ag- riculture. Agriculture, Ecosystems & Environment, 123(1- 3), 1-14.

Juuti, K., Lavonen, J., Salonen, V., Salmela-Aro, K., Schneider, B., & Krajcik, J. (2021). A teacher–researcher partner- ship for professional learning: Co-designing project-based learning units to increase student engagement in science classes. Journal of Science Teacher Education, 32(6), 625- 641.Keeling, R. P., & Hersh, R. H. (Eds.). (2017). Sustainability Curriculum Handbook: A Guide for Curriculum Development in Higher Education. Taylor & Francis.

Kumar, A., Samadder, S. R., & De, S. (2017). A review of technological options of waste to energy for effective management of municipal solid waste. Waste Management, 69, 407-422.

Luna Scott, C. (2015). The Futures of Learning 3: What kind of pedagogies for the 21st century?

update: Calendula officinalis Linn. Inventi Impact: Planta Activa, 4, 195-204.

Mochizuki, Y., & Fadeeva, Z. (2010). Competences for sustainable development and sustainability: Significance and challenges for ESD. International Journal of Sustainability in Higher Education, 11(4), 391-403.

Mohini P Barde (2012). Statistical Analysis of Data in Research Methodology: A Step-by-Step Handbook. Sage Publications.

Ouyang, F., Xu, W., & Cukurova, M. (2023). An artificial intelligence-driven learning analytics method to examine the collaborative problem-solving process from the com- plex adaptive systems perspective. International Journal of Computer-Supported Collaborative Learning, 18(1), 39-66.

Sady, M.,Żak, A., & Rzepka, K. (2019). The role of universities in sustainability-oriented competencies development: Insights from an empirical study on Polish universi- ties. Administrative Sciences, 9(3), 62.

Savery, J. R., & Duffy, T. M. (1995). Problem based learning: An instructional model and its constructivist framework. Educational Technology, 35(5), 31-38.

Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., & Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others? Teaching and Teacher Education, 27(2), 259-267.

Shepherd, M., & Cosgriff, M. (1998). Effective learning and practical application in education.

Sterling, S. (2001). Sustainable education: Re-visioning learn- ing and change. Green Books.

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. Review of Educational Research, 81(1), 4-28.

Tilley, D. R., & Lu, X. S. (2011). Recycling and composting as sustainable practices: A comparative analysis. International Journal of Environmental Studies, 68(3), 389-401.

Tipton, E., & Furmanek, D. (2016). Problem-based learning and academic performance: Empirical evidence from un- dergraduate business education. Active Learning in Higher Education, 17(2), 135-147.

UNESCO. (2014). Shaping the future, we want: UN Decade of Education for Sustainable Development (2005-2014). UNESCO.

Wals, A. E. J., & Jickling, B. (2002). "Sustainability" in higher education: From doublethink and newspeak to critical thinking and meaningful learning. International Journal of Sustainability in Higher Education, 3(3), 221-232.