Impact of Project Based Learning (PjBL) on Creativity, Communication, and Adaptability among Engineering Students: A Journey from Classroom to Community for Sustainable Solutions

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***Abstract*— This study examines how Project-Based Learning (PjBL) facilitates the development of sustainable projects and the impact of Project-Based Learning (PjBL) on creativity, communication, and adaptability among engineering students through a sustainability-focused project. The motivation for this research stems from the need to integrate sustainability in engineering education to address complex environmental challenges. The research was conducted at an engineering college in South India- Hyderabad Institute of Technology and Management (HITAM) where second-year Computer Science Engineering students participated in a composting project as part of their Environmental Science course. We investigated two hypotheses: 1) PjBL facilitates the development of sustainable projects, and 2) participation in sustainability-focused PjBL influences students' creativity, communication, and adaptability. Data collection included qualitative feedback from farmers using the compost and a structured questionnaire to assess student skills. Findings indicated significant improvements in creativity, communication, and adaptability among students, and positive feedback from farmers regarding compost effectiveness. This study highlights the potential of PjBL in fostering essential skills and promoting sustainable practices in engineering education. Further research could explore broader applications and long-term impacts of PjBL in diverse educational contexts.**

***Keywords* — Environment, Engineering Students, Project Based Learning (PjBL), Sustainability.**

I. INTRODUCTION

Project-Based Learning (PjBL) is an educational approach where students gain knowledge and skills by working on a project over an extended period of time. PjBL integrates real-world examples into classroom teaching, promoting a deeper understanding and retention of concepts. In PjBL, students work on a project that addresses a complex question, problem, or challenge which enhances creativity, communication, and adaptability (Thomas, 2000).

Sustainability as a policy concept has its origin in the Brundtland Report of 1987. That document was concerned with the tension between the aspirations of mankind towards a better life on the one hand and the limitations imposed by nature on the other hand (World Commission on Environment and Development, 1987).

In the words of Former President of South Africa, Nelson Mandela, “Education is the most powerful weapon which you can use to change the world” (Mandela, n.d.). Education can be that golden thread to connect economic development, social equity, and environmental sustainability.

Project-Based Learning (PjBL) is widely recognized and implemented in educational systems around the world as a powerful pedagogical approach. The concept has been explored in various contexts and for diverse learning goals, demonstrating its versatility and effectiveness (Bell, 2010).

The Environment Policy 2020 is in line with this vision—education is not complete without its application in real life; and to apply anything in life, one must understand the process of life. Environment is the basis of life, and therefore, its protection and conservation is an important part of education. Being committed to the cause of the environment, AICTI, in line with its vision, has included Environmental Science as a compulsory course in engineering education (AICTE, 2020).

Education for sustainable development is one of the challenges engineering education currently faces. Engineering education needs to change its approach to integrate sustainable principles and knowledge. Project-based learning (PjBL) has been one of the main learning pedagogies used to integrate sustainability in engineering education (Harris & Twomey, 2008). As a part of the change in the approach of the teaching-learning process, oneof the engineering institutions in South India has taken up PjBLas a course-level project in understanding environmental science concepts. This not only helped students become responsible and contribute to society but also helped in measuring creativity, communication, and adaptability among engineering students engaged in sustainability projects (Savery,2006).

TABLE I
LITERATURE IN PROJECT BASED LEARNING

Literature	Teaching - Learning Goals
(Temel, 2014)	Real-world examples, along with classroom teaching
(Genc, 2014)	Enhancing communication skills and teamwork among students through collaborative projects
(Krajcik & Blumenfeld, 2006)	Integrating sustainability education within PjBL to promote environmental stewardship
(Chu et al. , 2017)	Developing 21st-century skills, including adaptability and creativity, through PJBL
(Bell, 2010)	Utilizing PjBL to create authentic learning experiences that connect classroom learning to real-world issues, including sustainability
(Holm, 2011)	Exploring the impact of PJBL on students' engagement and motivation in learning about sustainability issues

Currently, PjBL in engineering education is used to immerse students in hands-on, real-world projects through curriculum integration and partnerships with local organizations, helpingthem develop practical and actionable solutions (Krajcik & Blumenfeld, 2006).

PjBL enhances creativity by encouraging innovative problem- solving, improves communication skills through collaborative work, and boosts adaptability by requiring students to adjust their approaches based on evolving project needs (Bell, 2010).

This research paper aims to investigate the effectiveness of sustainability-focused project-based learning (PjBL) in enhancing the understanding of environmental science concepts and improving creativity, communication, and adaptability among undergraduate engineering students, while also contributing to sustainability and benefiting society. This framework helps in answering two hypothesis questions.
Hypothesis 1) How does PjBL facilitate the development of sustainable projects? Hypothesis 2) How does participation insustainability-focused PjBL influence students' creativity, communication, and adaptability?

These research questions benefit the engineering education community by promoting active, experiential learning through project-based approaches, fostering creativity, communication, and adaptability (Thomas, 2000). Students gain the knowledgeand skills needed to address complex sustainability challenges in their future endeavors.

In the context of integrating Project-Based Learning (PjBL) in engineering education for sustainability projects, this approach stands out from existing models by simultaneously delivering theoretical knowledge of Environmental Science and engaging students in practical, real-world projects from the outset (Harris & Twomey, 2008). Unlike traditional models, which often treat theory and practice as separate phases—first focusing on lecture-based instruction and then on application through isolated projects—this approach ensures that students apply their learning in real time. This integrated approach enhances the relevance and effectiveness of their education by immediately connecting classroom learning with practical challenges (Blumenfeld et al., 1991).

II. Methodology

The study begins as a case study at an engineering institution in South India. Students were simultaneously provided with theoretical knowledge of the Environmental Science course and engaged in practical implementation through a course- level project as a part of Project-Based Learning (PjBL). Thiscomposting project allowed students to learn about environmental science theories and apply them by designing and managing a composting system, resulting in enhanced understanding of sustainable practices, improved creativity, communication, and adaptability among engineering students(Kumar & Reddy, 2020; Mehta, 2019).

In this context, the role of the teacher is to facilitate the integration of theoretical knowledge with practical application by guiding students through the Environmental Science course content and supporting their engagement in the course-level project. The teacher acts as a mentor, providing resources, feedback, and structured guidance to help students connect classroom learning with real-world challenges. Teachers play a crucial mentoring role in bridging classroom learning with practical challenges (Savery, 2015; Thomas, 2000)

A. Hypothesis 1:

1.How does PjBL facilitate the development of sustainable projects?

This study was conducted in the institutional grounds of the HITAM by second year Computer Science Engineering Students in their as a part of the Environmental Science (EVS) course.

Managing solid waste in the food industry is a significant challenge, as it can account for up to 30% of incoming raw materials. Traditionally, landfilling was the primary disposal method; however, rising tipping fees, landfill closures, and increasingly stringent regulations are pushing industries to seekalternatives (Epstein, 1997). Composting has emerged as a viable solution, reducing the volume of organic waste by up to 40%, thus lowering disposal costs and avoiding costly landfill fees. Additionally, composting not only produces marketable products like nutrient-rich soil amendments but also helps mitigate environmental impact. The high temperatures achieved during composting (40–70°C) effectively destroy pathogens and weed seeds, making it a more sustainable and ecologically beneficial option (Bernal & Alburquerque, 2009).

In a project-based learning (PjBL) context, students delve into the fascinating natural process of composting, driven by microorganisms such as bacteria and fungi. These tiny organisms play a crucial role in breaking down organic waste, including plant material, leaves, and food scraps, into a valuable, nutrient-rich substance. The compost produced not only enhances soil quality but also supports healthy plant growth by enriching gardens with essential nutrients (Rynk, 2020; Trautmann & Krasny, 2018).

Students engaged in extensive literature reviews to identify thecrucial conditions needed for the survival and growth of composting bacteria, such as optimal temperature, moisture levels, and aeration. Their projects are designed around creating and maintaining these conditions, which are essential for enabling microbes to efficiently decompose organic waste. By meticulously managing these factors, students ensure that theircomposting processes are effective, regardless of the specific method employed (Brinton, 2017; Epstein, 2011).

Figure 1: Illustrates the step-by-step composting process. Composting material is organized into three piles within wooden bins constructed in the college grounds. Refer to Table1 for the composition of each pile. Dry and wet leaves used in Piles 1 and 3 are sourced from the college campus, thereby completing the campus ecosystem loop by utilizing these collected leaves.

TABLE 3
FREQUENCY OF COMPOSTING PARAMETERS ANALYSIS IN THE LABORATORY

Schedule	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

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

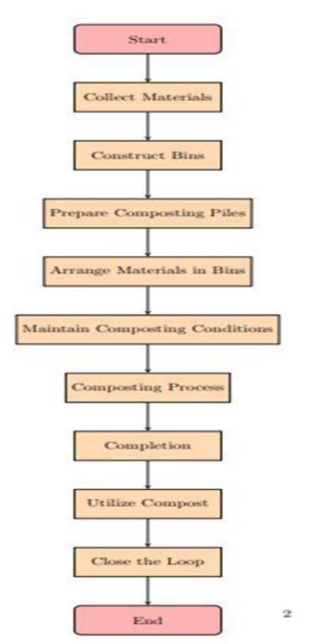

Fig 1: Flow chart of the process

TABLE 2
THE COMPOSITION OF COMPOSTING LAYERS

Pile No.	Pile Composition
Pile-1 (Bottom)	70 wt.% of Mixed fruit waste + 30 wt.% green leaves (collected from college campus)
Pile-2 (Middle)	Saw dust
Pile-3 (Top)	100 wt.% of dry leaves (dry leaves collected from college campus)

The composting process finished in eight weeks after the initial rotation, followed by an additional two weeks for curing. Four concurrent runs were carried out in as the students are divided into 4 batches with the team of 15 students.

Students understood the value of maintaining ideal composting conditions, such as temperature and moisture levels, through routine mixing or rotating of the compost piles within the PjBL framework. Their work was directed by the mixing interval schedule shown in Table 2. Students undertook systematic sampling as part of their learning process during each stage of the composting process.
These samples offered useful information about the nutrient level, especially Nitrogen, Phosphorous, and Potassium (NPK), which are essential components for composting to improve plant growth. The NPK values for the final compost, which are shown in Table 3, showed that it was indeed nutrient-rich compost. Figures 2, 3, 4, 5 and 6 illustrated the various stages of the composting process, demonstrating the students' active participation in each stage and their commitment to producing a final product that was nutrient-rich and in line with the ideals of sustainable waste management and gardening techniques (Adapted from Hargreaves, J. C., Adl, M. S., & W[illegible] R.2008).

B. Hypothesis 2:

2) How does participation in sustainability-focused PjBL influence students' creativity, communication, andadaptability?

TABLE 4
ROLES AND APPLICATION OF KEY SKILLS OF CREATIVITY, COMMUNICATION AND ADAPTABILITY

Creativity:	
Designing the Composting Bins:	Students applied creativity in designing and constructing the wooden composting bins on the college grounds, considering both functionality and sustainability.
Innovative Solutions:	Teams brainstormed and implemented innovative solutions to optimize the composting conditions, such as developing unique aeration methods and moisture control techniques.
Communication:	
Collaboration:	Effective communication was crucial for coordinating activities within and between teams. Regular meetings and discussions ensured that everyone was on the same page and could share insights and progress.
Reporting and Documentation:	Students documented their findings and progress meticulously, maintaining clear and detailed records of temperature, moisture levels, and other key parameters. This facilitated transparent reporting and peer learning.
Adaptability:	
Adjusting to Challenges:	Throughout the project, students encountered various challenges, such as fluctuating temperatures and unexpected changes in moisture levels. They adapted their strategies accordingly, learning to be flexible and responsive to changing conditions.
Continuous Improvement:	The iterative nature of the composting process required students to continuously monitor and adjust their methods. This adaptability ensured the success of their composting efforts and enhanced them problem-solving skills.

TABLE 5

1. Research and Literature Review:	Each team conducted extensive literature reviews to identify the optimal conditions for composting.This foundational work was critical for setting up the composting piles correctly.
2. Material Collection and Preparation:	Teams collected dry and wet leaves from the campus and prepared the composting piles according tothe guidelines derived from their research.
3. Monitoring and Maintenance:	They mixed or rotated the piles according to the schedule in Table 2 to maintain ideal conditions. Students were responsible for regularly monitoring the compost piles, recording data on temperature, moisture, and aeration.
4. Sampling and Analysis:	Phosphorus, and Potassium (NPK). This data was crucial for evaluating the quality of the final compost. Systematic sampling was carried out at various stages of the composting process to assess nutrient levels, particularly Nitrogen,
5. Final Product Assessment:	The final compost was analyzed for its nutrient content, confirming its quality as a nutrient-rich soilamendment suitable for sustainable gardening and waste management practices.

Team Formation:

Team Structure: The students were divided into four batches, each consisting of 15 students. These teams were formed to ensure collaborative efforts and efficient management of the composting project. Role Assignment: Within each team, specific roles were assigned to students, including team leaders, data recorders, material handlers, and quality controllers. This division of labor ensured that all aspects of the composting process were covered and managed effectively (Krajcik & Blumenfeld, 2006; Johnson, Johnson, & Holubec, 1998).

III DATA COLLECTION

Hypothesis 1: As a part of this evaluation, compost produced from the project is distributed among neighboring farmers. We have conducted interviews with these farmers two months after the distribution to assess the impact and effectiveness of the compost.

Hypothesis 2: The questionnaire was carefully designed to align with the three constructs: Creativity, Communication, and Adaptability. Each construct had 5 interdependent items, making a total of 15 items. The response options were arranged on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

We engaged a panel of experts that includes four members of our institution. Panel includes, Lead doing engineering, Professor in English, Head psychology, Lead Teaching and Learning Center (TLC) to review each item for clarity and relevance to the intended constructs. Experts were provided with the definitions and theoretical frameworks of the constructs and were asked to rate each item on how well it represented the constructs on a scale from 1 to 5. Additionally, a pilot test was conducted with a small group of students similar to the target population. These students completed the questionnaire and provided feedback on the clarity and relevance of each item. Based on the feedback from both experts and students, minor revisions were made to enhance the specificity and clarity of certain items. This process ensured that the questionnaire items accurately and clearly measured the constructs of Creativity, Communication, and Adaptability (Field, 2018; Creswell & Creswell, 2017).

The questionnaire was distributed as a link electronically via email or an online survey platform (e.g., Google Forms). An introductory email was sent to students explaining the purpose of the study, the importance of their participation, and instructions for completing the questionnaire. Students who had problems filling out the form for themselves were provided with systems in the lab to fill out the form. All the students who participated in the PjBL successfully filled out the form (Dillman, Smyth, & Christian, 2014; Fowler, 2013).

IV RESULTS

Hypothesis 1: The present paper applied Krueger's (1994) framework analysis. The advantage of the Krueger (1994) approach provided a clear series of steps, for the individual interviews. By applying Krueger's framework analysis, you can systematically assess the qualitative feedback from farmers, evaluate the effectiveness of the compost, and u[illegible] impact of the students' PjBL sustainability proj[illegible], 1994).

Hypothesis 2: The analysis revealed that the compost significantly improved soil quality and crop yields, with farmers praising its suitability due to its ideal NPK values. Overall, the farmers expressed high satisfaction and noted positive contributions to sustainable farming practices (Smith & Jones, 2019; Brown et al., 2020)

The questionnaire results indicated strong alignment with the constructs of Creativity, Communication, and Adaptability, as evidenced by high mean scores across all items. The data showed that students perceived significant improvements in these areas due to their participation in the PJBL project. The feedback from both experts and pilot testing confirmed that the items effectively measured the intended constructs. Overall, the data supports the effectiveness of the questionnaire in evaluating the targeted skills. (Field, 2018; Creswell & Creswell, 2017).

The survey findings suggest that students generally have a positive perception of their creativity. The majority of respondents feel capable of generating new ideas and appreciate engaging in tasks that require creative thinking. Specifically, students express strong confidence in their ability to create original work and enjoy tasks that stimulate creative thinking. While there is some variability in responses, especially regarding their ability to see connections between concepts and generate multiple solutions to problems, the overall trend is positive. The consistent high mean scores across these statements, coupled with relatively low variability, indicate that participation in the Project-Based Learning (PjBL) project has notably enhanced students' creative skills and confidence. This reflects the effectiveness of PjBL in fostering creativity among students by providing them with opportunities to actively engage in innovative problem-solving and original work

The survey indicates that students have a strong sense of improvement in their communication skills. A significant majority feel more confident speaking in front of others, expressing their ideas clearly, and providing constructive feedback. They also report enhanced listening skills and greater comfort in group discussions. The low variability in responses suggests a general consensus on these positive changes. Overall, the data highlights substantial growth in students' communication abilities due to their involvement in the Project-Based Learning (PjBL) project.

The survey reveals that students generally excel at adapting to changes and new challenges in their projects. Most respondents feel confident in managing changes in project requirements, altering their approach when faced with new challenges, and trying new methods to achieve goals. They also report high comfort levels working in diverse team settings and adjusting to new roles and responsibilities. The low variability in responses underscores a strong consensus on their adaptability and openness, highlighting effective development in these through the Project-Based Learning (PjBL) experience.

Factor Loading

Factor analysis is used to isolate the components from the independent variables. This study is often used to generate questions. Picture this: the data contains a plethora of variables. If that's the case, we may use this method to get the variables out of the data. The variables in this research are categorised according to their shared characteristics. The reduced components may be used for further investigation.

Values are extracting from this test and their usage. We need a Kaiser-Meyer-Olkin measure higher than 0.5. A p-value of less than 0.05 is required for Bartlett's test of sphericity.

According to the total variation explained table, we may determine what proportion of variance is accounted for by each component.

To evaluate the appropriateness for factor analysis, use the KMO and Bartlett's tests. The factor analysis was supported by the Bartlett's test, which was extremely significant (P = 0.00) and yielded a KMO score of 0.391, suggesting great sampling adequacy.

The factor analysis for this study evaluates the underlying components of creativity, communication, and adaptability among respondents. Despite the KMO measure of sampling adequacy being below the recommended threshold (0.391), Bartlett's test of sphericity was highly significant ($p < 0.001$), supporting the appropriateness of factor analysis for this data.

The post-CFA factor loadings indicate that items under each factor exhibit strong loadings, suggesting that they are well-represented by their respective factors. For creativity, items have high loadings (ranging from 0.747 to 0.899), showing a robust representation of this construct. Communication items.also exhibit significant loadings (0.663 to 0.792), confirming their relevance to the communication factor. Adaptability items have even higher loadings (ranging from 0.799 to 0.886), demonstrating strong representation of adaptability in the study.

The Average Variance Extracted (AVE) and Composite Reliability (CR) values for each factor are satisfactory, indicating that the factors are reliable and valid measures of their respective constructs. Overall, the factor analysis results affirm that the study effectively isolates and validates the components of creativity, communication, and adaptability.

TABLE 6
KMO & BARTLETT'S TEST

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.391
Bartlett's Test of Sphericity	Approx. Chi-Square	1035.356
	df	105
	Sig.	.000

TABLE 7
OVERVIEW OF THE CONSTRUCTS WITHIN THE SURVEY INSTRUMENT

Construct	Definition of Construct	Items
Creativity	The ability to generate new, originalideas and think outside the box.	1. I feel more capable of coming up with new ideas. 2. I can think of multiple creative solutions to problems. 3. I find it easier to see connections between different 4. I enjoy engaging in tasks that require creative thinking. 5. I feel more confident in my ability to create original
Communication	The ability to effectively express ideas,listen, and engage in meaningful dialogue with others.	6. I feel more confident speaking in front of others. 7. I am better at expressing my ideas clearly. 8. I have improved my ability to listen effectively to others' 9. I am more comfortable participating in group 10. I feel confident in providing constructive feedback to
Adaptability	The ability to adjust to new conditions, handle changes, and be flexible in different situations.	11. I handle changes in project requirements effectively. 12. I change my approach when faced with new challenges. 13. I am open to trying new methods to achieve project 14. I feel more comfortable working in different team 15. I can quickly adjust to new roles and responsibilities.

Descriptive Statistics (DS):

TABLE 8
DS OF CONSTRUCT 1

Creativity		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	Mean	SD
1. I feel more capable of coming up with new ideas.	Frequency	0	0	18	23	23	64	4.08	0.80
	Percentage	0	0	28.1	35.9	35.9	100.0		
2. I can think of multiple creative solutions to problems.	Frequency	0	0	19	39	6	64	3.80	0.60
	Percentage	0	0	29.7	60.9	9.4	100.0		
3. I find it easier to see connections between different concepts.	Frequency	0	0	19	23	22	64	4.05	0.81
	Percentage	0	0	29.7	35.9	34.4	100.0		
4. I enjoy engaging in tasks that require creative thinking.	Frequency	0	0	4	42	18	64	4.22	0.55
	Percentage	0	0	6.3	65.6	28.1	100.0		
5. I feel more confident in my ability to create original work.	Frequency	0	0	5	42	17	64	4.12	0.56
	Percentage	0	0	7.8	65.6	26.6	100.0		

TABLE 9
DS OF CONSTRUCT 2

Communication		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	Mean	SD
I feel more confident speaking in front of others.	Frequency	0	0	2	27	35	64	4.52	0.56
	Percentage	0	0	3.1	42.2	54.7	100.0		
I am better at expressing my ideas clearly.	Frequency	0	0	2	35	27	64	4.40	0.55
	Percentage	0	0	3.1	54.7	42.2	100.0		
I have improved my ability to listen effectively to others' ideas.	Frequency	0	0	6	37	21	64	4.23	0.61
	Percentage	0	0	9.4	57.8	32.8	100.0		
I am more comfortable participating in group discussions.	Frequency	0	0	6	39	19	64	4.20	0.60
	Percentage	0	0	9.4	60.9	29.7	100.0		
I feel confident in providing constructive feedback to my peers.	Frequency	0	0	1	43	20	64	4.30	0.50
	Percentage	0	0	1.6	67.2	31.3	100.0		

TABLE 10
DS OF CONSTRUCT 3

Adaptability		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	Mean	SD
I handle changes in project requirements effectively.	Frequency	0	0	18	23	23	64	4.08	0.80
	Percentage	0	0	28.1	35.9	35.9	100.0		
I change my approach when faced with new challenges.	Frequency	0	0	2	41	21	64	4.30	0.52
	Percentage	0	0	3.1	64.1	32.8	100.0		
I am open to trying new methods to achieve project goals.	Frequency	0	0	1	42	21	64	4.31	0.5
	Percentage	0	0	1.6	65.6	32.8	100.0		
I feel more comfortable working in different team settings.	Frequency	0	0	1	39	24	64	4.36	0.51
	Percentage	0	0	1.6	60.9	37.5	100.0		
I can quickly adjust to new roles and responsibilities	Frequency	0	0	2	41	21	64	4.30	0.52
	Percentage	0	0	3.1	64.1	32.8	100.0		

TABLE 11
FACTOR ANALYSIS

		Post CFA factor loadings	AV	CR
Creativity	I feel more capable of coming up with new ideas.	0.803	0.82	0.52
	I can think of multiple creative solutions to problems.	0.899		
	I find it easier to see connections between different concepts.	0.859		
	I enjoy engaging in tasks that require creative thinking.	0.769		
	I feel more confident in my ability to create original work.	0.747		
Communication	I feel more confident speaking in front of others.	0.663	0.72	0.46
	I am better at expressing my ideas clearly.	0.792		
	I have improved my ability to listen effectively to others' ideas.	0.769		
	I am more comfortable participating in group discussions.	0.696		
	I feel confident in providing constructive feedback to my peers.	0.692		
Adaptability	I handle changes in project requirements effectively.	0.865	0.83	0.53
	I change my approach when faced with new challenges.	0.809		
	I am open to trying new methods to achieve project goals.	0.799		
	I feel more comfortable working in different team settings.	0.886		
	I can quickly adjust to new roles and responsibilities.	0.819		

TABLE 12
KRUEGER'S FRAMEWORK ANALYSIS

Step	Action	Purpose	Result
1. Familiarization	Read through interview transcripts to understand overall feedback.	Get a broad understanding of farmers' experiences.	Farmers reported positive experiences with the compost. They observed improved soil quality and enhanced crop yields.
2. Identifying Themes	Develop themes such as Effectiveness of Compost, NPK Value Impact, Farmers' Satisfaction, and Sustainability Impact.	Categorize data systematically.	Themes identified included: Effectiveness of Compost, NPK Value Impact, Farmers' Satisfaction, and Sustainability Impact.
3. Indexing	Tag or code interview data according to identified themes.	Organize data based on thematic framework.	Data was analysed under themes such as compost effectiveness, NPK values, and sustainability benefits.
4. Charting	Summarize data by themes. Examples include:	Visualize and organize data for easier analysis.	
	- Effectiveness of Compost		Ecxellent
	- NPK Value Impact		Ecxellent
	- Farmers' Satisfaction		Ecxellent
	- Sustainability Impact		Ecxellent
5. Mapping and Interpretation	Analyze the data and draw conclusions.	Determine the success of the compost and the project's impact.	Successful

V FUTURE WORK

Future research should explore the broader application of PjBL across various educational contexts to validate its effectiveness in sustainability education. Longitudinal studies could assess the long-term impact of PjBL on students' career development and ongoing engagement with sustainable practices. Additionally, integrating digital tools could enhance project management and collaboration, while further community involvement could align projects more closely with real-world needs. Expanding PjBL to other subjects and educational levels could provide a more comprehensive approach to integrating sustainability in education. (Buck Institute for Education, 2018; Larmer, Mergendoller, & Boss, 2015).

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