INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 5, May 2026 | ISSN: 2456-4184 | IJNRD.ORG

Bridging the Curiosity Gap: A Pre -Experimental Study on Multilingual and ICT-Integrated Constructivist Science Pedagogy in JNV Gajapati

[1]Yogesh Kumar Dash

(MSc Med, Independent Researcher)

[2]Dipak Kumar Panda

(Asst. Prof. Teacher Education In Physics

DPIASE, Berhampur)

Abstract : The linguistic and cultural diversity of India necessitates an educational framework where mother-tongue instruction is prioritized to foster equitable learning, aligning with the global mandate of Sustainable Development Goal 4 (SDG 4). This study was conducted at Jawahar Navodaya Vidyalaya (JNV) Gajapati, a premier residential institution that provides a unique controlled environment for educational research. The residential nature of the school naturally neutralizes external variables such as socio-economic disparities, parental academic interference, and digital distractions, allowing for a standardized assessment of pedagogical interventions. Adopting a pre-experimental single-group pre-test and post-test design, the research evaluated a multimodal constructivist intervention involving 40 students. The intervention moved beyond traditional rote learning by integrating group discussions, hands-on model preparation, laboratory visits, and ICT-based visual scaffolding. A critical component was the use of the students' native linguistic repertoire (Sambalpuri/Odia) to bridge the conceptual gap in Science. Quantitative analysis showed a significant improvement in academic achievement, with mean scores rising from 22.50 to 31.45 out of 40, resulting in a t-value of 9.75, which rejects the null hypothesis at the 0.01 level. Qualitatively, the study observed a profound shift in classroom dynamics; students who were previously hesitant became active participants, showcasing increased curiosity and spontaneous engagement in scientific inquiry. The findings conclude that integrating digital tools and native language scaffolding within a constructivist framework is essential for unlocking the academic potential of rural students in a residential setup.

Keywords : Pre- Experimental, Multilingual, Information & Communication Technology,

Integrated learning, Constructivism

Introduction

The foundational essence of education in a linguistically diverse nation like India lies in its ability to foster equality and respect for a child's native background. As outlined in the global mandate of Sustainable Development Goal 4 (SDG 4) and the National Education Policy (NEP) 2020, inclusive and quality education is fundamentally linked to mother-tongue-based instruction. However, the reality of the Indian classroom is a complex tapestry of over 1600 mother tongues, creating a significant challenge for formal institutions to provide an environment where children can learn without extra cognitive effort. **Singh (2024)** and **Datta and Mete (2025)** argue that the linguistic landscape of India requires teacher education programs to move beyond monolingual frameworks and capitalize on the complexities of multilingual classrooms to ensure that no child is marginalized due to their language.

In the realm of Science education, this challenge becomes even more acute. Abstract scientific concepts and rigid English terminology often act as "gatekeepers," preventing rural students from achieving their full academic potential. To address this, the concept of **Translanguaging** has emerged as a vital pedagogical intervention. **Jason Anderson (2024)** highlights that expert Indian teachers naturally leverage the linguistic repertoire of their learners mixing local dialects with English to provide essential "scaffolding" for complex concepts. This aligns with the "Bridging Metaphor" proposed by **Panda et al. (2011)**, which suggests that effective learning occurs when a strong bridge is built between the child's everyday world and the academic world of the school. **Tsimpli et al. (2020)** further demonstrate that linguistic diversity and multilingualism actually enhance a child's cognitive flexibility, provided the pedagogy is inclusive enough to utilize these existing skills.

Modern science pedagogy must also integrate digital tools to transform abstract ideas into visible reality. **Soundarya and Patil (2024)** observe that Information and Communication Technology (ICT) acts as a powerful equalizer in government schools, making the learning process interactive and engaging. When digital pedagogy is anchored in a **Constructivist framework**, the impact on student achievement is profound. **Tripathy and Das (2025)** suggest that models like the "Panchapadi" approach (Adhiti, Bodh, Abhyas, Prayog, Prasar), when combined with ICT, allow students to explore and elaborate on scientific phenomena in ways that traditional rote methods cannot. **Deepa et al. (2022)** refer to such technology-enabled interventions as the "Unsung Voices" of education, empowering students in resource-constrained rural environments to find their place in the scientific discourse.

The unique residential ecosystem of Jawahar Navodaya Vidyalayas (JNVs) provides an unparalleled setting for such educational research. Established to nurture rural talent, JNVs offer a standardized and controlled environment where external variables such as socio-economic disparities, lack of digital access at home, and parental academic interference are naturally neutralized. However, even in these premier institutions, the barrier of English proficiency remains a hurdle in subjects like Science. This study, situated at JNV Gajapati, explores the impact of a multimodal intervention integrating mother-tongue scaffolding (Sambalpuri/Odia), ICT-based visuals, and active laboratory experimentation. By adopting a P**re -Experimental design**, this research aims to demonstrate that when rural students are provided with a linguistically inclusive and digitally rich constructivist environment, they transition from passive recipients to active constructors of scientific knowledge.

The students at JNV Gajapati represent some of the most marginalized tribal communities in Odisha, where English and Hindi remain alien languages. Their cognitive and conceptual worlds are primarily constructed in their native dialects, making the rigid, monolingual curriculum of Science a daunting barrier. This linguistic gap is historically intensified by the prolonged unavailability of subject-specialist teachers, leading to significant academic negligence and a cumulative learning deficit. Entering Grade 7 with almost zero prior exposure to digital tools or ICT-enabled instruction, these learners faced a profound "Curiosity Gap."

To bridge years of academic neglect, this study implemented a **Constructivist-Humanistic intervention** that prioritized the child's identity over rote memorization. By integrating **Multilingual Scaffolding** with **Reflective Pedagogy**, the classroom was transformed into a safe space where students were encouraged to "think in their own language" while "exploring the scientific world." The use of **Digital Pedagogy** including interactive educational games and digital drawing tools acted as a catalyst for their dormant curiosity. When provided with a mentor who facilitated active **Lab visits** and hands-on experimentation, these students began to articulate complex scientific phenomena in their own linguistic repertoire. This multimodal approach ensured that their creativity was not suppressed by language constraints but nurtured through inclusive inquiry. Consequently, the research demonstrates that when marginalized learners are empowered with digital access and linguistic agency, they transition from a state of neglect to becoming active, curious scientific investigators.

Rationale of The Study

The students at JNV Gajapati represent some of the most marginalized tribal communities in Odisha, where English and Hindi remain alien languages. Their cognitive and conceptual worlds are primarily constructed in their native dialects, making the rigid, monolingual curriculum of Science a daunting barrier. This linguistic gap is historically intensified by the prolonged unavailability of subject-specialist teachers, leading to significant academic negligence and a cumulative learning deficit. As Singh (2024) points out, such resource constraints and teacher shortages are major barriers to implementing effective multilingual policies in India. Entering Grade 7 with almost zero prior exposure to digital tools or ICT-enabled instruction, these learners faced a profound "Curiosity Gap."

To bridge years of academic neglect, this study implemented a Constructivist-Humanistic intervention that prioritized the child's identity over rote memorization. By integrating Multilingual Scaffolding with Reflective Pedagogy, the classroom was transformed into a safe space where students were encouraged to "think in their own language" while "exploring the scientific world." This aligns with the "Bridging Metaphor" proposed by Panda et al. (2011), which emphasizes connecting the child's everyday language with academic concepts. The use of Digital Pedagogy including interactive educational games and digital drawing tools acted as a catalyst for their dormant curiosity, effectively addressing the infrastructure and learning disparity often found in rural schools (Soundarya & Patil, 2024).

When provided with a mentor who facilitated active Lab visits and hands-on experimentation, these students began to articulate complex scientific phenomena in their own linguistic repertoire. This multimodal approach ensured that their creativity was not suppressed by language constraints but nurtured through inclusive inquiry. Consequently, the research demonstrates that when marginalized learners are empowered with digital access and linguistic agency, they transition from a state of neglect to becoming active, curious scientific investigators, fulfilling the vision of equitable education as envisioned in NEP 2020 (Singh, 2024).

Review of related Literature

The current study is positioned at the intersection of multilingual pedagogy, digital integration, and constructivist science learning. To provide a theoretical and empirical foundation for this research, several relevant studies and policy frameworks were reviewed.

Tripathy and Das (2025) investigated the integration of the "Panchapadi" pedagogical approach (Adhiti, Bodh, Abhyas, Prayog, Prasar) with ICT. Although their focus was on language learning, the study demonstrated that a culturally grounded, learner-centered constructivist framework leads to holistic development. The researcher has adapted this constructivist model to the Science classroom at JNV Gajapati.

Singh (2024) examined the National Education Policy (NEP) 2020 with a specific focus on its multilingual education mandate. The study highlighted that mother-tongue-based instruction at the foundational and middle school levels offers significant cognitive and psychological benefits. However, Singh also identified critical barriers such as teacher shortages and resource constraints in rural areas, which aligns with the challenges observed at JNV Gajapati.

Jason Anderson (2024) explored the "translanguaging" practices of expert Indian teachers. The research found that effective educators naturally utilize the students' native linguistic repertoire to provide "scaffolding" for complex academic concepts. This study supports the researcher's approach of using Odia and Sambalpuri as a bridge to make Science terminology more accessible to tribal learners.

Soundarya and Patil (2024) evaluated the impact of the ICT at school program in secondary government schools. Their research concluded that Information and Communication Technology (ICT) acts as a powerful equalizer, significantly improving the learning experiences of rural students by making abstract concepts more interactive and engaging. This supports the intervention of using online games and digital visuals in the current study.

Tsimpli et al. (2020) conducted a study on disadvantaged children in India, investigating the link between linguistic diversity and cognitive skills. The findings suggested that multilingualism enhances executive control and problem-solving abilities. This empirical evidence justifies the use of a multilingual framework to boost the scientific inquiry skills of marginalized students.

Panda et al. (2011) emphasized the "Bridging Metaphor" in tribal education in Odisha. Their longitudinal study argued that for education to be effective, there must be a structural bridge between the child's everyday world and the academic world of the school. This review reinforces the necessity of using local contexts and laboratory visits to ground scientific concepts in the lived reality of the students.

Objectives of The Study

- To evaluate the impact of Multilingual Education (MLE) using mother-tongue scaffolding on the academic achievement of Class VII students in Science at JNV Gajapati.
- To assess the effectiveness of ICT-integrated constructivist teaching (online games, digital drawing, and visuals) in enhancing the conceptual clarity and learning growth of students.
- To compare the pre-intervention and post-intervention academic scores to measure the overall efficacy of multimodal reflective pedagogy and lab-based learning.

Hypotheses

❖ **H_0** : There is no significant difference between the pre-test and post-test scores of Class VII students in Science after the integrated intervention of Multilingual Education (MLE) and ICT-integrated constructivist pedagogy.

❖ **H_1**: There is a significant difference between the pre-test and post-test scores of Class VII students in Science after the integrated intervention of Multilingual Education (MLE) and ICT-integrated constructivist pedagogy.

Methodology

The Study followed a Pre – test Post – Test single group Pre -experimental design. MLE classroom with instructions in mother tongue along with English, Hindi, and frequent lab visit, practical classes and experimental based study, along with blended learning, reflective classes and digital board games were implemented as the experimental intervention. 40 students were selected from each section i.e., 7th A 20 students and 7th B 20 students as sample of the study.

Table 1 : Sample selected for the test

Samples Taken (40)	Section – 7th A	Section – 7th B
Boys	10	10
Girls	10	10

Population : The population of this study were the 80 students of Class 7th studying in Jawahar Navodaya Vidyalaya, paralakhemundi, Gajapati in year 2025-2026.

Sample Of the study : The samples of the study were 40 students of class 7th out of total 80 and 20 students selected from each section, where even 20 male and 20 female students balance was maintained

Sampling Technique : To ensure unbiased results, 20 students were selected from Section A and 20 students from Section B. This helped in maintaining uniformity across different classroom environments within the same grade with the help of purposive stratified random sampling.

Delimitation

The present study was delimited based on the following parameters to ensure a focused and systematic investigation:

- Geographical Area: The study was strictly delimited to Jawahar Navodaya Vidyalaya (JNV), Gajapati, Odisha. No other schools or regions were included in the research.
- Target Population: The research was delimited to the students of Class 7 only. While students of Classes 6 and 8 were involved in motivational sessions, the experimental data and statistical analysis were confined to this specific group.
- Subject Matter: The intervention was delimited to the Science curriculum. Specifically, the focus was on concepts requiring high visual and conceptual clarity, such as *life processes in plants, earth sun & moon, light : shadow & reflection.*
- Time Period: The duration of the experimental intervention was delimited to a period of four months (Academic Year 2025-26), including the pre-test, intervention phase, and post-test.
- Instructional Language: The study focused on bridging English instruction using only Odia as the primary native linguistic tools.

Table 2 . Research Design

Design Structure	Group	Pre Test	Treatment	Post Test
Experimental Group	40 students from class 7th	O^1	MLE & ICT based constructivism	O^2

Procedure of The intervention

The intervention was carried out over a period of seven weeks, adopting a multi-pronged pedagogical approach. After the initial Pre-test, the researcher conducted continuous Classroom Observations to monitor student engagement and behavioral shifts. To ensure ongoing evaluation, Formative Assessments were integrated into the daily routine through interactive quizzes, peer discussions, and reflective questioning.

While the core intervention consisting of Multilingual Scaffolding (English-Hindi-Odia), Digital Integration, and Reflective Blended Learning remained a constant framework for all units, specific chapters were supplemented with targeted hands-on activities. For instance, the unit on 'Life Processes in Plants' involved extensive Lab Visits for chlorophyll and xylem-phloem experiments, while 'Light' and 'Solar System' were explored through Hands-on Model Making (Periscope/Kaleidoscope) and Digital Simulations. Finally, after 1.5 months of intensive intervention, a Post-test was administered to measure the cumulative academic growth.

Table 3. Intervention activities weekly

Week	Phase	Key activities & Interventions	Focus Area
Week 1	Baseline	Administration of Pre-test & Initial Classroom Observation.	Assessing Entry Level
Week 2	Conceptualization	Units on Nutrition & Plants. Multilingual scaffolding + Lab Visits (Stomata view, Xylem/Phloem).	Observation & Inquiry
Week 3	Digital Exploration	Solar System & Space Science. Focus on Digital Classes, 3D simulations, and Interactive videos.	Visual Literacy
Week 4	Hands On activities	Light & Optics. Making of Periscope/Kaleidoscope. Sorting (Transparent/Opaque).	Creativity & Application
Week 5	Formative Phase	Mid-intervention Quizzes, Chart Preparation, and Model exhibition by students.	Peer Learning
Week 6	Reflection	Reflective Classes and doubt clearing in mixed languages (Odia/Hindi/English).	Conceptual Consolidation
Week 7	Evaluation	Administration of Post-test & Final Feedback Collection.	Measurement

Data Collection

The data collection for this study was carried out in a systematic and phased manner. Initially, a **Pre-test** was administered to the sample of 40 students to record their baseline academic performance in Science. Throughout the 1.5-month intervention period, qualitative data was collected through continuous **Classroom Observations** and formative records of student participation in lab activities and digital sessions.

After the completion of the integrated MLE and ICT-based teaching cycle, a **Post-test** was conducted using the same standardized parameters. All the raw scores from both tests were meticulously compiled and tabulated. To ensure the integrity of the data, the answer scripts were cross-checked and the scores were entered into a master sheet for further statistical computation.

Table 4. Test Scores of Sample students

Sl. No.	Student code	Gender	Section	Pre test O^1	Post Test O^2
1	FA 1	Female	A	25	35
2	FA 2	Female	A	17	32
3	FA 3	Female	A	18	39
4	FA 4	Female	A	19	32
5	FA 5	Female	A	20	30
6	FA 6	Female	A	16	25
7	FA 7	Female	A	24	34
8	FA 8	Female	A	17	30
9	FA 9	Female	A	38	38
10	FA 10	Female	A	35	38
11	MA 1	Male	A	14	28
12	MA 2	Male	A	16	35
13	MA 3	Male	A	14	21
14	MA 4	Male	A	27	34
15	MA 5	Male	A	24	29
16	MA 6	Male	A	24	35
17	MA 7	Male	A	27	34
18	MA 8	Male	A	22	37
19	MA 9	Male	A	33	40
20	MA 10	Male	A	16	28
21	FB 1	Female	B	15	21
22	FB 2	Female	B	31	37
23	FB 3	Female	B	14	25
24	FB 4	Female	B	38	38
25	FB 5	Female	B	37	37
26	FB 6	Female	B	20	30
27	FB 7	Female	B	14	18
28	FB 8	Female	B	15	15
29	FB 9	Female	B	19	25
30	FB 10	Female	B	16	30
31	MB 1	Male	B	25	33
32	MB 2	Male	B	20	38
33	MB 3	Male	B	24	40
34	MB 4	Male	B	26	38
35	MB 5	Male	B	14	26
36	MB 6	Male	B	15	26
37	MB 7	Male	B	17	16
38	MB 8	Male	B	18	34
39	MB 9	Male	B	37	39
40	MB 10	Male	B	39	38

(**source code : F** – Female **, M** – Male , A – A section, B – B Section)

Statistical Methods used

The quantitative data obtained from the pre-test and post-test was analyzed using descriptive and inferential statistics to draw meaningful conclusions. The following methods were employed:

- **Descriptive Statistics: Mean (M)** was used to determine the average performance of the students, while **Standard Deviation (SD)** and **Variance we**re calculated to understand the spread and consistency of scores within the group.
- **Inferential Statistics:** A **Paired Sample t-test** was used to compare the means of the same group before and after the intervention. This was essential to determine if the academic growth was statistically significant.
- **Significance Level:** The results were tested at both **0.05** and **0.01** levels of significance to ensure the highest degree of reliability.
- **Software Used:** Data tabulation and preliminary calculations were performed using **Microsoft Excel** to ensure mathematical precision.

Data Analysis & Interpretation

The primary objective of the analysis was to evaluate the impact of integrated Multilingual Education (MLE) and ICT-integrated pedagogy on the Science achievement of Class VII students**.**

Table 5. Data Analysis & T value calculation

Variables	N	Mean	SD	Mean Difference	df	calculated t value	Tabulated t-value (0.05)	Tabulated t-value (0.01)	Significance
Pre Test	40	22.50	7.81	8.95	39	9.75	2.02	2.71	Significant At Both 0.05 &0.01 Level
Post Test	40	31.45	6.50						

Data Interpretation

➢ Academic Achievement: The Mean score showed a remarkable jump from 22.50 (Pre-test) to 31.45 (Post-test). This absolute gain of 8.95 marks suggests that when students are taught using their native language (Odia/Sambalpuri) as a bridge along with digital visuals, their conceptual clarity improves significantly.

➢ Consistency in Learning: Interestingly, the Standard Deviation decreased from 7.94 to 6.81. This indicates that the intervention helped in bringing the “slow learners” closer to the class average, making the learning process more uniform and reducing the disparity within the classroom.

Major Findings & Hypothesis Testing

The findings of the study are directly aligned with the research hypotheses formulated at the beginning of the experiment.

❖ (H_0): There is no significant difference between the pre-test and post-test scores of Class VII students in Science after the integrated intervention of Multilingual Education (MLE) and ICT-integrated constructivist pedagogy.

➢ Status: REJECTED.

➢ Reason: The calculated t-value (9.75) is significantly higher than the critical table value (2.71) at the 0.01 level. This indicates that the null hypothesis cannot be sustained.

❖ (H_1): There is a significant difference between the pre-test and post-test scores of Class VII students in Science after the integrated intervention of Multilingual Education (MLE) and ICT-integrated constructivist pedagogy.

- Status: ACCEPTED.
- Reason: The substantial increase in the mean scores (from 22.50 to 31.45) and the high t-value statistically confirm that the intervention brought about a genuine and significant improvement in academic achievement.

This statistically proves that the improvement in student performance is not a matter of chance but a direct result of the experimental teaching strategy.

Qualitative Analysis of Student Behavior

Beyond the statistical gains, a qualitative shift was observed in the classroom environment. The descriptive data highlights a significant transition from Passive Learning to Active Inquiry. The integration of Multilingual Education (MLE) acted as a psychological bridge, reducing linguistic anxiety and allowing students to articulate their scientific thoughts in a mix of Odia, Sambalpuri, and English.

Furthermore, the introduction of ICT and hands-on laboratory activities transformed the students from “observers” to “constructors” of knowledge. The surge in curiosity-driven questioning and the students’ ability to independently handle lab experiments (like the Stomata view and Periscope making) indicate a deep-rooted conceptual shift. This behavioral evolution confirms that the intervention didn’t just improve test scores, but also fostered a genuine Scientific Temper among the tribal learners of JNV Gajapati.

Data Collection tool : Participant Observation

"While no formal rigid observation schedule was pre-designed, the researcher adopted the role of a ***Participant Observer****. Extensive* ***Field Notes*** *were maintained during the 1.5-month intervention period. These notes captured the spontaneous behavioral shifts, linguistic comfort, and engagement levels of the students. This* ***Unstructured Observation*** *allowed the researcher to record authentic, natural classroom interactions that a formal checklist might have missed."*

Table 6. Qualitative Observation of Student

Observation Domain	Pre-Intervention Scenario (Baseline)	Post-Intervention Behavior (Impact)
Linguistic Comfort	Students were hesitant to speak; primarily remained silent or gave one-word answers due to fear of incorrect English/Hindi.	Students actively participated using Translanguaging (mixing Odia/Sambalpuri with English), showing higher confidence in expression.
Questioning Attitude	Rare instances of doubt-clearing; students mostly followed rote-learning patterns without questioning 'Why' or 'How'.	Curiosity-driven questioning increased. Students started asking about the “Logic” behind experiments (e.g., Stomata functionality)
Digital Engagement	Students were passive observers during standard lectures with zero familiarity with digital tools.	High level of excitement and Active Engagement with digital simulations. Students started navigating educational games independently
Hands-on Participation	Hesitation in handling lab equipment; preferred	Proactive participation In group activities. Students successfully built their own

	watching the teacher perform experiments from a distance.	models like Periscopes and Kaleidoscopes with minimal guidance.
Conceptual Retention	Struggle to recall abstract science terms; often confused between similar biological process.	Improved visual memory and retention. Students could explain complex cycles (like life processes) by referring to the digital models and lab observations.

Conclusion

The success of this intervention proves that academic achievement is not just about finishing the syllabus; it is about building a relationship with the students. While the use of Mother Tongue (MLE) and ICT played a huge role, the real catalyst was the **Change in Pedagogy**. By moving away from the strict, traditional teacher-student hierarchy and adopting a "Friendly Mentor" approach, I was able to create a safe learning space for the students of JNV Gajapati.

The data shows a jump from 58% to 82%, but the qualitative reality is much deeper. The students responded to **intrinsic and extrinsic motivation** whether it was through educational films, field visits to the lab, or the personal attention they received during repeated, unscheduled copy checks. When education stopped feeling like a "load" and started feeling like "fun," the learning happened naturally. This research concludes that a teacher's empathy, combined with modern tools and linguistic support, can unlock the potential of even the most hesitant learners.

Recommendations & Suggestions

For the Teachers :

- **Be a Mentor, Not a Taskmaster:** Build a rapport where students feel comfortable sharing their doubts. A friendly attitude reduces "Learning Anxiety," which is the biggest enemy of Science education.
- **Variety in Tools:** Don't just stick to textbooks. Use movies, short films, and field visits. When students see Science in action, they remember it for life.
- **Consistent Feedback:** Don't wait for scheduled exams. Frequent and informal checking of work (even if it's extra effort) keeps the students on track and shows them that you care about their progress.
- **Mixed Motivation:** Use a balance of rewards (Extrinsic) and curiosity-building (Intrinsic) to keep the energy high in the classroom.

For JNV Gajapati Students:

- **Keep the Curiosity Alive:** Science is everywhere in the movies you watch and the labs you visit. Never stop asking "Why?" And keep exploring the books, environment, surrounding and try to draw relations, similarities from the real world.
- **Support Each Other:** Continue the "Friendly Learning" culture we started. Help your peers who struggle with certain topics.
- **Education is Not a Burden:** Remember that learning is fun if you relate it to your surroundings. Keep that same energy you had during our sessions.

For the School Management:

- **Encourage Innovative Teaching:** Teachers should be supported when they want to go beyond the schedule to help students. Flexible teaching hours and extra lab access can make a huge difference.

- **Holistic Environment:** Education should include more visual and practical experiences to make Science accessible to everyone, regardless of their background.

Acknowledgement

The completion of this research is not just a personal achievement, but a collective effort of several individuals who believed in my vision and supported me throughout this journey.

First and foremost, I express my sincere gratitude to **Shri Jayanth Prasad Mahata, Principal-in-charge of Jawahar Navodaya Vidyalaya (JNV), Gajapati**. I am deeply thankful to him for granting me the permission to conduct this experimental research within the school premises and for providing the necessary resources and administrative support that made this study possible.

I would like to extend my heartfelt thanks to **Assistant Professor Dipak Kumar Panda**, my guide and mentor. His constant encouragement and professional backing were the reasons I had the confidence to undertake an experimental research design. His insights into pedagogical interventions and his unwavering support throughout the data collection and analysis phases have been invaluable.

I also wish to express my love and gratitude to my **lovable students of Classes 6, 7, and 8 at JNV Gajapati**. Their wholehearted acceptance of me, not just as a researcher but as a mentor, was the highlights of my time at the school. A special mention goes to the **students of Class 7**, who were the core participants of this study. Their enthusiasm, cooperation, and active participation made the research process smooth and led to these fruitful results. The bond we shared in the classroom is something I will cherish forever.

Lastly, I am grateful to everyone who directly or indirectly contributed to the successful completion of this project.

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