

1. Title of the Case Paper of Practice

- **Name of the initiative:**

Gene Expression (Better learning with Technology).

- **Corresponding Sub theme od Stem Education:**

Experiential Learning through motivated STEM Teachers.

- **School Name:**

Burnpur Riverside School, Chittaranjan.

- **Address of the School:**

Near CLW Health Centre, Fathepur, Chittaranjan.

- **School Affiliation Number:**

2430124

- **State:**

West Bengal.

- **Concerned COE:**

COE Bhubaneswar.

- **Presented by:[TEAM]**

Niladri Sen and Prabhat Kumar.

- **Contact Details of the presenter:**

8240608159/7584003990

- **Date and Occasion:**

22/07/2025 STEM DLD hosted by Burnpur Riverside School, Burnpur.

2. Introduction

- **Background/Context:**

Gene expression is the heart of all biological processes and has a resounding connection to Genetics, Biochemistry, Biotechnology and Medicine evolution. It connects us to the real world in terms of physical similarities and differences that all of us feel and experience throughout our lives. We adopted a multifaceted approach, strategically designed to cater to diverse learning styles and progressively elevate students through Bloom's Taxonomy.

- **Problem or need addressed:**

The concept that we are covering here is abstract and complex as it involves microscopic elements. Theoretical understanding and rote memorization cannot suffice the very need of this very important aspect of our lives. It also requires conceptual understanding, reasoning and analysis.

- **Target group and timeline:**

Students of Class 12 (Biology)

3 periods

3. Objectives:

- **Learning outcomes targeted:**

- a) Foundational and Core Conceptual Clarity (**Remember and Understand**) on -
 - ✓ Transcription
 - ✓ Translation
 - ✓ Incomplete Dominance
 - ✓ Co-Dominance
 - ✓ Multiple Allelism
 - ✓ Dihybrid Cross (Statistical Summary on results)
- b) Process and Mechanism comprehension (**Understanding**).
- c) Development of scientific temperament.
- d) Gain practical insights into learning gene expression.

- **STEM skills or competencies focused:**

- ❖ Experiential learning
- ❖ Reasoning
- ❖ Analysis
- ❖ Conceptual Understanding
- ❖ Biological modelling
- ❖ IT skills
- ❖ Data Interpretation
- ❖ Design Thinking
- ❖ Mathematical (Punnet Square using Matrices)

4. Description of the Practice:

✓ **What was done?**

Open ended questions were asked to the class related to the examples of allele, Heuristics approach was used to bring about the previous knowledge stack of Mendel's law, Punnet square of Incomplete dominance and codominance were displayed on the smart board for **visual stimulation**, - these step ensures **(remembering and understanding)** lower level of Bloom's taxonomy.

Model of gene expression from DNA  were given as a role play among children to stimulate kinesthetic and **audio stimulation**- this will impart middle level of Bloom's taxonomy (applying, analyzing),

They finally will be called to make a DNA structure from a strip of paper and an RNA Polymerase from a piece of dough and ultimately structure of gene expression from dough. These will impart higher level of Bloom's taxonomy **(Evaluating, and Creating)** thus bringing about **Kinesthetic learning**.

✓ **How was it conducted?**

Our execution prioritized active participation and diverse sensory inputs:

- ✓ **Interactive Questioning:** The session commenced with direct, open-ended questions to immediately involve students and assess their preconceptions.
- ✓ **Auditory Engagement:** A thematically relevant song was performed, providing a creative and memorable way to introduce or reinforce concepts.
- ✓ **Visual Demonstration:** Slides showcasing Punnett squares were leveraged for clear visual understanding.
- ✓ **Experiential Learning:** The student role-play was a cornerstone, allowing them to embody the molecular processes.
- ✓ **Tactile Modelling:** The dough demonstration for incomplete dominance and codominance provided a tactile way to explore abstract genetic concepts.
- ✓ **Digital Simulation:** A simulation of incomplete dominance was played, designed specifically to enhance inquisitiveness and allow students to visualize genetic outcomes dynamically.

✓ **Materials/Tools used**

Chemical clay of three different colours like red, White, black or red, yellow and black, piece of papers. IT tools like Ms-Powerpoint and simulation tool made it easy for interpretation.

5. Methodology:

• **Pedagogical Approach:**

Experiential learning, Role-Play, Interactive method, Inquiry based method and Demonstration method with Prime focus on Heuristics approach (to check the preconceived learning and adjust the lesson accordingly).

• **Role of students and teachers:**

The role of students was learning by doing, conceptualizing their learning outcomes and that of the teachers was that of a motivated STEM teacher which involves being a Creative thinker, Facilitator, motivator and encourager. Also it proved to be a multimodal approach to shift to an even better student friendly dynamic.

• **Curriculum Integration:**

Biology with

Chemistry (Concept of Biomolecules)

Physics (Molecular movements)

Concept of Cell Theory

Human health

Societal (Real world aspects)

Mathematics (Punnet Square)

Technology through IT

6. Evidence-Based Impact:

Student Learning Outcomes:

"Beyond anecdotal success, the pedagogical strategies we've implemented for Gene Expression are firmly rooted in educational research, demonstrating a clear and evidence-based impact on student learning outcomes. Our approach consistently leads to deeper understanding, improved retention, and the development of crucial higher-order thinking skills, critical for success in STEM.

- ✓ Enhanced conceptual understanding and retention.
- ✓ Developing a scientific temperament and inquisitiveness among students.
- ✓ Increased engagement and motivation.
- ✓ Ownership of learning (intrinsic motivation).

When students can connect scientific concepts to real-world phenomena and manipulate variables through simulations, their ability to apply knowledge and solve problems in novel contexts significantly improves.

Testimonials, Student products or outcomes:

Engagement or behavior changes:

- It reduced passivity.
- Brought about creativity.
- Increased participation rates.
- Open ended questions increased.
- Emotional connection through story-telling, role play and songs.

- Active seeking of clarification.

7. Novelty and Relevance:

Unique aspects of the practice:

- ❖ Beyond chalk and talk.
- ❖ Elevating Blooms Taxonomy.
- ❖ Abstract to tangible.
- ❖ Blend of Traditional Pedagogy with modern tools and creativity.

Connection to real world problems or current trends:

Understanding gene expression is not merely an academic exercise, it is the bedrock of modern biology and a powerful tool for addressing some of the most pressing real-world problems and driving groundbreaking innovations globally, and increasingly, within India. By teaching gene expression comprehensively, we empower students to be informed citizens and potential contributors to these critical fields. Personalised medicine and healthcare, Biotechnology and industrial applications, Agriculture and food security and emerging technologies which require gene mapping.

8. Inclusivity and Equity:

Participation of diverse student groups:

a) Catering to diverse learning styles (**Learning Diversity**):

Use of **visuals (smartboard, simulations), auditory input (song), and kinesthetic activities (role-play, dough modelling)** directly addresses the spectrum of learning styles.

- **Visual Learners:** Benefit from the clear diagrams, Punnett squares, and dynamic simulations.
- **Auditory Learners:** Engage through open-ended questions, class discussions, and the specially incorporated song.
- **Kinesthetic/Tactile Learners:** Thrive in the role-play, and particularly the hands-on creation of DNA/RNA polymerase from paper and dough. This is crucial for students who struggle with abstract concepts presented only verbally or visually.

b) Encouraging students to ask questions and thereby enhance participation. (**Behavioural Diversity**).

c) Addressing Varying Prior Knowledge and Conceptual Gaps (**Academic Diversity**).

Gender balance, students with disabilities, under-presented groups:

- ❖ Active participation by all.
- ❖ Curiosity and active questioning make students who rarely present themselves to respond thereby promoting inclusiveness.

9. Scalability and Replicability:

Potential to implement in other schools:

Low-Cost Materials: The reliance on readily available and inexpensive materials like paper strips and dough/chemical clay makes the hands-on modeling components highly accessible. These are materials any school, regardless of its budget, can procure.

Leveraging Existing Technology: While a smartboard and simulation tool were used, the core principles of visual display and interactive learning can be adapted. Projectors, simple computers, or even well-drawn charts can serve similar visual purposes. The essence is the interactive demonstration, not necessarily the cutting-edge technology.

Human Resources: The primary resource required is a teacher willing to embrace a facilitative, student-centred role, which is a professional development opportunity rather than a capital expense.

What You See Is What You Believe: Our topic can be directly experienced in the real world, we are only trying to bring out the abstract nature of internal components to physical structure and states to promote understanding and applying.

Necessary conditions for replication:

While the potential for wider implementation of our Gene Expression teaching methodology is significant, successful replication across diverse school settings hinges on addressing several critical enabling conditions. These conditions are not barriers, but rather strategic areas of focus to ensure the fidelity and efficacy of the approach in new environments.

- a) Professional Development and empowerment of teachers.

- b) Flexible curriculum and Time allocation.
- c) Basic resources and infrastructure will do.
- d) Adaptation in Assessment (Do away with rote learning).

Documentation available:

- a) Lesson Plan enclosed.
- b) Activity Guides.
- c) Teacher reflections.

10. Sustainability and cost effectiveness:

Long-Term Viability:

- Core Principles Over Specific Tools.
- Continuous Improvement cycle.
- Minimizing reliance on high-cost infrastructure.
- Reusable materials and concepts.
- Promotion of Experiential learning which is the need of the hour.
- Move beyond rote memorization.
- Preparing our children for application-oriented future trends.

Budget used and cost saving methods:

Chemical Clay/Dough: (Approx. ₹50-100 per student/group, depending on quantity and reusability)

- This is an extremely economical material that can be reused for multiple sessions or different topics if stored properly.

Paper Strips: (Negligible cost, often sourced from recycled paper or inexpensive stationery packs – approx. ₹10-20 per student/group for a full unit)

- Simple bond paper or coloured paper, easily cut into strips, forming the backbone for DNA models.

Stationery (Scissors, Glue, Markers): (Already existing classroom supplies, shared among students)

- No specific new purchases were typically needed for these basic tools.

Classroom Display Materials (Chart Paper/Whiteboard): (Standard classroom supplies)

- Used for initial brainstorming, group outputs, or quick diagrams.

Use of Local or low-cost materials:

Chemical Clay / Dough:

- **Versatility:** This is arguably the most versatile and impactful low-cost material used. It allows students to physically mold and represent complex 3D molecular structures (DNA, RNA polymerase), distinguish different bases or amino acids through color, and even illustrate abstract concepts like the distinctness in codominance or the blending in incomplete dominance.
- **Accessibility:** Clay or flour for dough is universally available in India, making it a sustainable and culturally familiar material.
- **Tactile Engagement:** Its malleable nature provides unique tactile feedback, enhancing kinesthetic learning.

Paper Strips:

- **Simplicity and Abundance:** Readily available from discarded paper, old notebooks, or inexpensive stationery.
- **Structural Modeling:** Perfect for constructing linear molecules like DNA (representing base pairs or the sugar-phosphate backbone) and RNA, allowing students to physically connect the components and understand their linear arrangement.
- **Creative Construction:** Promotes fine motor skills and spatial reasoning as students cut, fold, and assemble.

Standard Stationery: Scissors, glue, and markers are ubiquitous in schools. Our activities maximize their use without demanding specialized art or lab supplies.

Reduced Waste: Compared to specialized lab kits with single-use components or chemical reagents, our use of reusable clay/dough and paper minimizes waste, aligning with broader environmental sustainability goals.

Long-Term Feasibility: The low consumption of materials ensures the program remains financially viable for continuous implementation year after year, without requiring schools to constantly seek new funding for consumables.

11. Learnings and Reflections:

Challenges faced and solutions:

The Problem:

In many Indian schools, including ours, large class sizes (often 40+ students) can make individualized attention and managing hands-on activities seem daunting. Ensuring every student gets an opportunity to participate effectively without chaos is a significant concern.

Our Solution:

Strategic Grouping and Role Assignment: We implemented a system of small, pre-assigned groups (e.g., 4-6 students) for activities like role-play and dough modeling. Within each group, specific roles were assigned (e.g., "DNA template," "RNA polymerase," "amino acid carrier," "recorder," "presenter"). This ensured accountability and active participation from every member.

Key insights and improvements for the future:

Profound Impact of Multimodal Engagement: The most significant insight is the undeniable power of catering to diverse learning styles simultaneously. Combining visual, auditory, and especially kinesthetic (role-play, dough modelling) inputs drastically deepens comprehension and enhances retention of complex biological processes, far beyond what traditional methods achieve.

The Transformative Power of "Creation": Moving beyond just "understanding" to "creating" (Higher Bloom's Taxonomy) through tangible models forces students to synthesize, evaluate, and apply their knowledge at the highest level. This is where true mastery becomes evident.

Engagement Drives Understanding: When students are genuinely engaged through interactive activities, their motivation skyrockets, leading to reduced disciplinary issues and a more vibrant, inquiry-driven classroom atmosphere.

Low-Cost, High-Impact Feasibility: We unequivocally demonstrated that high-quality, hands-on STEM education does not

require prohibitive budgets. Resourcefulness with local and low-cost materials can yield exceptional learning outcomes, making it highly scalable.

Teacher as a Facilitator is Key: The success hinges on the teacher's shift from a content deliverer to a skilled facilitator who guides discovery, asks probing questions, and trusts the student's learning journey.

12. Conclusion:

Summary of the impact:

- Elevated Student Learning Outcomes.
- Increased Engagement and Positive Behavioral Shifts.
- Demonstrated STEM Integration.
- Proof of Scalability and Sustainability.
- Direct Connection to Real-World Relevance.

Future vision or next steps:

1. District-Wide Rollout and Teacher Training Programs.
2. Curriculum Expansion and Interdisciplinary Integration.
3. Leveraging Emerging Technologies for Enhanced Learning.

Our future vision is clear: to cultivate a generation of scientifically literate, critically thinking, and innovative young minds who are not just prepared for examinations, but are truly equipped to tackle the complex challenges and seize the opportunities of the 21st century.

Questions/feedback welcome: