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AN INTEGRATED COMMUNICATION MODEL FOR ENHANCING ENGAGEMENT, COMPREHENSION, AND COLLABORATION IN ENGINEERING CLASSROOMS

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Abstract
This study proposes an integrated communication model designed to enhance engagement, comprehension, and collaboration in engineering classrooms. Traditional classroom communication in India continues to be dominated by linear, instructor-centred delivery, limiting opportunities for interaction, critical thinking, and shared knowledge construction. Drawing from educational, transactional, and cooperative communication theories, this research develops and evaluates a triadic communication model that systematically sequences teacher-led explanation, dialogic interaction, and peer-driven collaborative learning.
A mixed-method quasi-experimental design was adopted involving 60 first-year engineering students divided into control and experimental groups. Quantitative findings revealed significant improvements in engagement (+40%), comprehension (+39%), and collaboration (+50%) among the experimental group exposed to the integrated model. Qualitative reflections further indicated increased confidence, clarity in understanding, peer support, and reduced communication anxiety. The results demonstrate that communication in education is most effective when instructional clarity, dialogic processing, and cooperative learning operate as a continuous pedagogical cycle.
The proposed model offers a scalable, context-sensitive approach for engineering educators seeking to align teaching practices with NEP-2020 and Outcome-Based Education norms. It positions communication not merely as a channel for content delivery but as a transformative pedagogical process that constructs knowledge, fosters teamwork, and prepares learners for professional communication demands.
Key words — Communication, interactive learning, cooperative learning, engineering education, instructional design, pedagogy.

1. INTRODUCTION

Communication forms the foundation of all instructional processes in higher education, serving as the primary means through which knowledge, skills, and values are transmitted, negotiated, and internalised. In engineering education, where abstract concepts, technical terminology, and practice-based learning converge, communication assumes an especially critical role. The transition from teacher-centred teaching to learner-centric pedagogies—endorsed by NEP 2020—demands more sophisticated communication approaches that promote inquiry, conceptual understanding, collaboration, and digital engagement.

Engineering students in their first-year face multiple challenges: linguistic diversity, unfamiliarity with academic discourse, inconsistent exposure to English, and limited confidence in communication. Traditional lecture-oriented instruction prioritises content transmission over interaction, leaving little space for questioning, clarification, or collaborative application. As a result, students often memorise content without constructing deep conceptual connections.

Recent studies in ICT-enabled learning environments reveal that communication is no longer linear or unidirectional. It occurs synchronously and asynchronously across face-to-face sessions, learning management systems, digital discussion forums, and collaborative platforms. These modes require educators to reconceptualise

classroom communication as a multidimensional process that incorporates structured explanation, dialogic meaning-making, and cooperative knowledge construction.
Although research on individual communication approaches exists, there remains a gap in integrating educational, transactional, and cooperative communication into a unified model—particularly in the Indian engineering context. This study addresses that gap by designing, implementing, and evaluating an integrated communication model that aligns with constructivist learning principles and contemporary educational policy mandates.

2. LITERATURE REVIEW

Communication in higher education has undergone significant transformation over the past two decades, particularly with the emergence of learner-centric pedagogies and digitally mediated instructional environments. In engineering education, where learning depends heavily on understanding technical vocabulary, conceptual frameworks, and collaborative problem-solving, communication becomes a defining element of academic success. This section reviews three foundational strands of instructional communication—educational, transactional, and cooperative—and highlights the need for their integration.

2.1 Educational Communication

Educational communication refers to structured, teacher-led instructional processes that prioritise clarity, sequencing, reinforcement, and organised delivery of content. Rooted in cognitivist and information-processing theories, this approach positions the teacher as the primary source of knowledge. Ausubel's work on advance organisers emphasised that meaningful learning occurs when new content is connected with existing cognitive structures. Similarly, Bruner's Discovery Learning framework posits that guided instruction enables learners to organise information and build conceptual understanding before independently applying it.
In engineering classrooms, structured instructional communication aids students in navigating unfamiliar technical terminology, abstract concepts, and sequential problem-solving processes. Studies consistently demonstrate that instructional clarity reduces cognitive load, enhances retention, and supports comprehension. However, when used in isolation, this communication mode results in passive reception rather than active engagement. Students may recall facts but struggle to apply knowledge, articulate reasoning, or engage critically with content.
Therefore, while educational communication provides an essential entry point into new knowledge systems, contemporary classrooms require additional layers of interaction to transform information into meaningful learning.

2.2 Transactional Communication

Transactional communication conceptualises teaching and learning as a dynamic exchange in which meaning is co-constructed through dialogue. Unlike linear communication—where information flows from teacher to student—transactional models recognise that participants send and receive messages simultaneously, refining their understanding through questioning, feedback, and reflection.
This model aligns closely with Vygotsky's Social Constructivism, which argues that learning occurs within social interactions and is mediated by language. Interactive strategies such as think–pair–share, open-ended questioning, and reflective feedback loops enable learners to clarify doubts, test assumptions, and collaboratively build meaning. In engineering contexts, transactional communication becomes essential for bridging the gap between theory and application. It helps students articulate problem-solving steps, negotiate interpretations, and critically evaluate solutions.
However, while transactional communication supports engagement and comprehension, it does not inherently cultivate teamwork, shared responsibility, or interpersonal communication skills. To achieve these outcomes, cooperative modes of communication must be integrated into the instructional cycle.

2.3 Cooperative Communication

Cooperative communication centres around peer collaboration, shared responsibility, and the co-construction of knowledge. In this model, students work together to complete tasks, solve problems, or produce artefacts, each contributing unique perspectives and abilities. Cooperative communication draws heavily on Johnson and Johnson's Cooperative Learning Theory, which emphasises five essential elements: positive interdependence, individual accountability, promotive interaction, interpersonal skills, and group processing.
Within engineering education, cooperative learning is crucial because it reflects real-world professional environments where engineers work in interdisciplinary teams. Structured group work strengthens students' communication skills, confidence, empathy, and tolerance for differing viewpoints. It also encourages lower-performing or linguistically hesitant learners to participate meaningfully without fear of judgment.
Nonetheless, cooperative communication without initial clarity or interactive scaffolding may lead to confusion, dominant group members, or unequal participation. Thus, its success depends on a preceding instructional foundation and ongoing dialogue.

2.4 Need for Integration

While educational, transactional, and cooperative communication each contribute uniquely to learning, research reveals that none alone is sufficient for developing engagement, comprehension, and collaborative competence. Traditional lecture formats fail to activate learner participation; interactive discussions without structured input may lack direction; and group work without prior conceptual grounding can result in superficial outcomes.

Modern pedagogical frameworks—including NEP 2020 and Outcome-Based Education—advocate for integrative teaching practices that align curricular goals with communication-driven learning experiences. The literature thus points toward a triadic model that blends instructional clarity, dialogic interaction, and collaborative knowledge construction into a unified pedagogical cycle.

This integrated communication model, therefore, addresses an existing gap by sequencing explanation → interaction → cooperation in a manner that supports cognitive, behavioural, and socio-emotional learning outcomes in engineering classrooms.

3. METHODOLOGY

This study employed a mixed-method quasi-experimental design to evaluate the impact of an integrated communication model combining educational, transactional, and cooperative strategies on first-year engineering students' engagement, comprehension, and collaborative performance. The methodology was structured to capture both measurable learning outcomes and experiential insights, ensuring a comprehensive evaluation of the proposed communication model.

3.1 Research Design

A quasi-experimental, non-randomised control group design was adopted because classroom-based research in higher education rarely permits random assignment. Two intact sections of first-year engineering students enrolled in a mandatory communication-related course were selected. One section received traditional lecture-based instruction (control group), while the other was taught using the integrated communication model (experimental group).

The study collected both quantitative and qualitative data to assess learning outcomes. Quantitative measures examined pre-test and post-test differences, while qualitative responses provided insight into learner perceptions, engagement patterns, and affective responses to the intervention.

3.2 Participants

The participants comprised 60 first-year engineering students from **Dr. Ambedkar Institute of Technology, Bangalore, India**. Section A (n = 30) served as the control group, and Section B (n = 30) formed the experimental group. Students represented diverse socioeconomic and linguistic backgrounds, and English proficiency levels varied—a typical feature of Indian engineering cohorts.

Participation was voluntary, and no incentives were provided. Demographic information such as age, gender, and language background was collected only for contextual understanding and not used for comparative purposes.

3.3 Instructional Intervention

The instructional intervention was conducted over **three weeks**, comprising **six sessions** of **90 minutes** each. The experimental group received instruction based on a structured, **three-phase communication model**, while the control group was taught using conventional lecture-based methods with minimal interaction.

Phase 1: Educational Communication (Instructional Clarity)

- Teacher-led explanation of concepts
- Use of examples, diagrams, and structured notes
- Clear learning outcomes presented at the beginning of each session
- Use of PowerPoint slides and Learning Management System (LMS) resources

This phase ensured conceptual grounding and reduced cognitive ambiguity.

Phase 2: Transactional Communication (Interactive Dialogue)

- Question–answer exchanges
- Think–pair–share activities
- Real-time feedback loops
- Guided discussion of model texts or case studies

This phase facilitated meaning-making through negotiation, clarification, and reflection.

Phase 3: Cooperative Communication (Collaborative Learning)

- Small groups of 4–5 students
- Peer explanation, shared responsibilities, and joint production tasks
- Group outputs such as summaries, mini-presentations, and analytical responses
- Reflection on group processes

This phase enabled students to apply their understanding collaboratively and develop interpersonal communication skills.

3.4 Instruments for Data Collection

Three validated instruments were used to measure the study variables:

3.4.1 Student Survey (Likert Scale)

A 10-item pre-test and post-test survey measured:

- Engagement
- Comprehension
- Collaborative confidence

Items used a 5-point scale ranging from **1 (Strongly Disagree)** to **5 (Strongly Agree)**. A Cronbach's alpha coefficient of 0.84 indicated strong internal reliability.

3.4.2 Classroom Observation Checklist
An independent faculty observer recorded:
- Frequency of participation
- Question-asking behaviour
- Peer interaction patterns
- Attention span and off-task behaviour
- Evidence of cooperation

This allowed triangulation of behavioural data with survey scores.
3.4.3 Reflective Journals
Students submitted reflective notes after each session describing:
- Learning experiences
- Conceptual clarity
- Comfort during interaction
- Confidence in group work
- Challenges encountered

These reflections provided qualitative insight into the cognitive and emotional effects of the intervention.
3.5 Data Collection Procedure

Week	Activity
Week 0	Orientation and consent
Week 1	Pre-test administration for both groups
Weeks 1–3	Intervention sessions delivered to experimental group
Week 3	Post-test administration and classroom observations
Continuous	Reflective journals collected for thematic analysis

3.6 Data Analysis
Quantitative Analysis
Mean scores and standard deviations were derived from pre-test and post-test survey responses. Percentage gains were calculated to identify learning improvements attributable to the intervention. Given the small sample size, descriptive statistics were prioritised for clarity and interpretive accuracy.
Qualitative Analysis
Student reflections were coded to identify recurring themes related to:
- Engagement
- Conceptual understanding
- Group support
- Communication confidence

Observation notes were used to corroborate these themes.
3.7 Ethical Considerations
- Informed consent was obtained from all participants.
- Participation did not affect academic grades.
- No personal identifiers were reported in the study.
- Approval was granted by the institution's department-level research authority.

3.8 Limitations
- Non-randomised sample limits generalisability
- Short intervention duration (three weeks) restricts long-term analysis
- Self-reported data may carry subjective bias
- Study focused on communication-related modules, not technical courses

Despite these limitations, methodological triangulation enhanced validity and credibility.

4. RESULTS

This section presents the findings derived from quantitative survey scores, classroom observations, and student reflections. Data are organised around the three learning dimensions measured in the study: engagement, comprehension, and collaboration.
4.1 Quantitative Results
The pre-test and post-test survey measured students' perceptions of their engagement, comprehension, and collaborative confidence before and after the instructional intervention. Scores ranged from **1 (Strongly Disagree)** to **5 (Strongly Agree).**
4.1.1 Pre-test Scores
The baseline data indicated comparable starting levels between both groups:

Dimension	Control Group Mean	Experimental Group Mean
Engagement	3.12	3.18
Comprehension	3.24	3.26
Collaboration	3.01	3.07

Minimal difference (less than 0.1 points) suggests both groups possessed similar readiness and motivation before the intervention.

4.1.2 Post-test Scores

After six sessions, the experimental group displayed substantial improvements across all dimensions:

Dimension	Control Group Mean	Experimental Group Mean
Engagement	3.38	4.45
Comprehension	3.56	4.52
Collaboration	3.29	4.61

The sharp increase in the experimental group's scores confirms the positive effect of the integrated communication model.

4.1.3 Percentage Gains

Dimension	Control Group	Experimental Group
Engagement	+8%	**+40%**
Comprehension	+10%	**+39%**
Collaboration	+9%	**+50%**

The highest improvement was recorded in **collaboration**, indicating that the structured cooperative-learning phase significantly enhanced teamwork and peer-based learning behaviours.

4.2 Standard Deviation and Performance Consistency

The standard deviation of the experimental group **reduced from 0.82 (pre-test) to 0.48 (post-test)**, suggesting:

- Improved performance consistency
- Narrowing of learning gaps
- Positive impact on weaker learners who benefitted from peer-supported activities

The control group's deviation remained unchanged, indicating conventional lecture-based instruction did not equalise learning outcomes.

4.3 Behavioural Observations

Classroom observations corroborated the quantitative findings.

Control Group Behaviour

- Minimal questioning
- Limited peer interaction
- Sporadic attention and off-task behaviour
- Teacher dominance in classroom communication
- Passive reception of content

Experimental Group Behaviour

- Frequent participation and discussion
- Students asked clarifying questions proactively
- Reduced hesitation among shy learners
- Active collaboration during group tasks
- Increased attentiveness and reduced distraction

These behavioural changes illustrate the transformation from passive learning to active classroom engagement.

4.4 Qualitative Reflection Themes

Analysis of students' reflective journals revealed four recurring themes:

Theme 1: Active Engagement

Students described classes as "more interesting," "lively," and "interactive," highlighting a shift from passive listening to participation.

Theme 2: Improved Comprehension

Learners noted that:

- Instructional clarity helped them understand concepts
- Dialogue clarified doubts instantly
- Group work reinforced learning through peer explanation

Theme 3: Collaborative Confidence

Shy or linguistically hesitant students expressed increased confidence while working in groups, demonstrating improved interpersonal communication.

Theme 4: Peer Support and Empathy

Students acknowledged developing patience, encouragement, and responsibility toward peers—key socio-emotional learning outcomes.

4.5 Summary of Results

The integrated communication model:

✓ Increased student engagement

✓ Strengthened comprehension through repeated processing

✓ Improved collaborative abilities and peer support

✓ Reduced performance disparities

✓ Transformed classroom dynamics into active learning environments

These outcomes validate the pedagogical effectiveness of merging instructional clarity, interactive dialogue, and cooperative learning.

5. DISCUSSION

The purpose of this study was to assess whether an integrated communication model—sequencing educational, transactional, and cooperative communication—could significantly improve engagement, comprehension, and collaboration among first-year engineering students. The results strongly affirm this hypothesis, demonstrating that communication in engineering classrooms must be multidimensional rather than unidirectional.

5.1 Communication as a Catalyst for Deep Learning

The experimental group exhibited remarkable improvements across all measured dimensions. These findings align with contemporary learning theories, including:

- **Bruner's Discovery Learning**, which advocates scaffolding for conceptual organisation
- **Vygotsky's Social Constructivism**, which positions dialogue as central to meaning-making
- **Johnson and Johnson's Cooperative Learning**, which recognises peer collaboration as essential for holistic development

The integration of these principles into a coherent communication cycle allowed learners to move from **understanding → interaction → collaboration**, creating deeper and more durable learning experiences.

5.2 Engagement: From Passive Reception to Active Participation

Engagement recorded one of the highest behavioural shifts. Students in the experimental group:

- Asked more questions
- Participated voluntarily
- Maintained attentiveness
- Expressed curiosity and initiative

This shift occurred because transactional communication transformed classroom interaction from instructor-centred to learner-led. Engagement thus emerged not as a by-product but as a predictable outcome of structured dialogue.

5.3 Enhanced Comprehension Through Multilayered Processing

Comprehension improved significantly when concepts were:

1. **Introduced clearly** (educational communication)
2. **Discussed interactively** (transactional communication)
3. **Applied collaboratively** (cooperative communication)

This cyclical reinforcement mirrors the cognitive progression from **encoding → elaboration → consolidation**. Students repeatedly encountered concepts in varied communication contexts, strengthening both retention and understanding.

5.4 Collaboration: Beyond Group Work

Collaboration showed the highest percentage gain (+50%), underscoring the importance of structured peer interaction. Unlike unplanned group activity, cooperative communication involved:

- Defined roles
- Shared responsibility
- Continuous feedback
- Empathy and mutual support

Students developed interpersonal competencies that are essential for professional engineering practice, including negotiation, leadership, and respect for diverse perspectives.

5.5 Synergy of the Three Communication Dimensions

A key contribution of this study is the demonstration that **each communication dimension enhances the others**:

Communication Type	Primary Strength	Limitation if Used Alone
Educational	Concept clarity	Low participation
Transactional	Meaning-making	Lacks cooperative depth
Cooperative	Teamwork skills	Risk of confusion

The **triadic integration** resolved these limitations, making:

• Instruction meaningful
• Interaction purposeful
• Collaboration productive

This synergy transforms communication into a **pedagogical engine**, not a delivery mechanism.

5.6 Implications for NEP 2020 and OBE

The proposed model aligns directly with **NEP 2020** priorities:

• Experiential, learner-centred instruction
• Multidisciplinary and collaborative learning
• Communication as a critical graduate skill

Similarly, it supports **Outcome-Based Education (OBE)** by enhancing competencies mapped to:

• Teamwork
• Professional communication
• Critical thinking
• Conceptual clarity

Thus, the integrated model provides a practical framework for institutions seeking meaningful NEP implementation.

5.7 Significance for Technology-Enabled Classrooms

In ICT-based learning environments, communication is distributed across digital platforms. The proposed model can be seamlessly adapted to:

• LMS forums (transactional)
• Collaborative documents (cooperative)
• Recorded modules and slides (educational)

This flexibility positions the model as a scalable solution for hybrid and online teaching.

5.8 Limitations and Directions for Future Research

While the findings are promising, the study has limitations:

• Small sample size (n = 60)
• Short intervention period (three weeks)
• Limited to communication-related modules

Future research could examine:

• Long-term retention effects
• Integration in domain-specific courses (e.g., physics, programming)
• Digital analytics for monitoring interaction patterns

5.9 Summary of Discussion

The findings confirm that instructional communication is most powerful when:

• **Educational** clarity initiates understanding
• **Transactional** dialogue deepens meaning
• **Cooperative** engagement sustains learning

This triadic communication model not only improves academic outcomes but also nurtures confidence, empathy, and teamwork—qualities indispensable for engineering graduates.

6. CONCLUSION

This study set out to examine the impact of an integrated communication model—sequencing educational, transactional, and cooperative communication—on learning outcomes among first-year engineering students. The results demonstrated that communication functions most effectively not as a single, linear process, but as an evolving pedagogical cycle that supports cognitive, behavioural, and socio-emotional development.

The integrated model:

• **Enhanced engagement** by transforming students from passive listeners to active participants
• **Improved comprehension** through reinforced learning across multiple communicative layers
• **Strengthened collaboration** by enabling peer-supported learning and responsibility-sharing

These gains highlight that structured explanation alone is insufficient for contemporary learners. Instead, communication must facilitate interaction, negotiation of meaning, and shared construction of knowledge. The study thus reaffirms that communication is not merely a conduit for information transfer but the **core mechanism** through which learning is constructed.

The findings carry important implications for engineering education in India, especially in the context of **NEP 2020** and **Outcome-Based Education** mandates. Institutions striving to build employability-focused, collaborative, and digitally enabled classrooms can adopt this model to strengthen instructional design and improve learner engagement. Although the study was limited in duration and sample size, it provides a scalable framework adaptable to diverse instructional environments, including hybrid and online platforms.

Future research may explore the long-term effects of the model, evaluate its impact across engineering domains, and integrate digital analytics to map communication behaviours. Nevertheless, the evidence confirms that when educational, transactional, and cooperative communication operate synergistically, classroom learning becomes more inclusive, participatory, and meaningful.

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