INTERNATIONAL JOURNAL OF EDUCATIONAL AND SCIENTIFIC RESEARCH

ISSN: 2635-3148

website: www.worldresearchacademy.com

SURVEY OF THE LANGUAGE STRUCTURE, FUNCTIONAL ROLES, AND INTERCONNECTIVITY ON THE INDUSTRIAL PRODUCTION LINE: A STUDY OF PURE BIOTECH COMPANY, MAKURDI

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Abstract

This study investigated the language structure, functional roles, and interconnectivity and operational outcomes on an industrial production line. Using a mixed-methods case study of Pure Biotech Company (Makurdi), the study combines a structured operator/technician questionnaire (N = 82), semi-structured interviews with supervisors and line managers (n = 10), and systematic observation of line interactions during three production shifts. Quantitative analyses (descriptive statistics, multiple regression) and qualitative thematic analysis were used. The study is grounded in two theories- Shannon and Kleaver's Communication Model and system theory by Bertalanffy.

Findings of the study indicated that (i) clear, standardized language conventions for task descriptions and fault signals are positively associated with reduced error rates and faster fault resolution; (ii) well-defined functional role language (role labels, procedural scripts) improves role clarity and coordination; and (iii) interconnectivity (technical and communicative) mediates the relationship between language structure and line performance. In conclusion and recommendations, the study recommended among other things that multilingual glossary be developed and displayed within the company's premises to enhance effective communication.

Key words: language structure, language function, language connectivity, industrial production line.

Introduction

Language is the medium through which human beings pass information, a vehicle of expression, emotions and thoughts to one another. It is used in daily activities mainly for the purpose of communication. According to Sapir (1921), language is a purely human and non-instinctive method of communicating ideas, emotions and desires by means of a system of voluntarily produced symbols. In the words of Chomsky (2006), language is a cognitive system, part of the mind/brain that enables humans to generate and understand an infinite range of sentences from a finite set of rules. These definitions point to the fact that language is used for different purposes and in different ways. Language could be viewed according to structure, function and connectivity. According to Bhatia (2019), language structure deals with the form and organization of language elements; language function focuses on what language is used for (purpose); while language connectivity refers to how language link communication across teams, machines and stages. Language words and expressions are used differently by different people or organizations for different purposes. According to Odozi (2022), there are registers that are used according to the different fields of human endeavors, specialized terms (jargons) understood only within the industry or company and informal and contextual codes (slang) used among peers to ease tension.

Effective communication on the production line is a central determinant of operational performance, safety, and knowledge transfer. Recent studies show that language proficiency and clarity significantly affect knowledge sharing, productivity and safety outcomes in industrial settings (Canestrino et al., 2022; Guillouet et al., 2021). Language-related misunderstandings at work correlate with reduced performance and negative attitudinal outcomes among employees.

Functional role clarity (who does what, handoffs) and interconnectivity (how people and systems exchange information — e.g., digital dashboards, machine alerts, mobile apps) are tied to the Industry 4.0 literature: more interconnected systems can improve information flow and decision speed but demand clear linguistic and procedural standards to avoid misinterpretation. Studies on smart factories and Industry 4.0 confirm that information and communication integration is a crucial success factor for modern production lines.

Safety and productivity research emphasizes that safety-communication quality (clear signage, standardized instructions, and language-appropriate training) reduces accidents and supports commitment to safety practices. Systematic reviews highlight the link between safety communication and safety outcomes in high-risk workplaces. Meanwhile, recent practical reports and surveys document measurable productivity loss where language barriers exist; these losses scale with organizational size and complexity, especially where tacit knowledge transfer is required. Advances in natural-language tools (e.g., LLM-based knowledge retrieval) are emerging as potential aids for knowledge sharing on the factory floor.

Few empirical studies combine (a) fine-grained measurement of language *structure* (terminology clarity, instruction syntax), (b) functional-role clarity, and (c) digital interconnectivity — and relate them simultaneously to production metrics (throughput, defects, and downtime) in a single company context. This study fills that gap with a mixed-methods case study at Pure Biotech Company, Makurdi.

Language structure in the production line of Pure Biotech Company, Makurdi

The language structure of production lines according to Adewale and Orumanyi (2022), is grouped into verbal, visual and symbolic/technical codes. Relatedly, Nweke (2022), classified the structure of an industrial communication under-technical terms/jargons, symbolic and visual language, standard operation procedures (SOPs) among others. These classifications are similar to the structural language in Pure Biotech Company, Makurdi with little disparity. In Pure Biotech Company, Makurdi, the language structure is connected verbally, visually, symbolically and through jargon used by operators in the company. A visit to the company revealed the language structure as discussed below:

- **Verbal language structure:** The staff of the company communicate to one another and to customers verbally. At the level of workers, they communicate verbally for shift handovers, giving instructions for tasks to be carried out. There is also verbal communication between staff and customers who usually bring cassava (fresh tubers/chips) for sale at the company. This verbal communication helps with immediate feedback, clarity and saves time. This shows an interactional use of language among staff and transactional use of language between customers and members of staff.

- **Visual language structure:** These are visible signs that convey information. At the Pure Biotech Company, Makurdi, the floor is marked with arrows, humans and vehicular images. These show direction, walkways for humans, road direction or cargo etc.

Consider the image below:

Cargo way.

- **Symbols**: these are different symbols at the Pure Biotech Company. Symbols showing areas of restriction, smoking, danger zones indicating that humans are to avoid designated areas during production, buttons with different colours on machines indicating-power-on, power-off, among others. Below are some of these symbols:

- General warning
- Stop or emergency
- Fire hazard
- Radiation hazard
- Fire extinguisher location

Jargon: operational jargons such as bioreactor sterilization point, fermentation are known terms used in the company under study. Other examples of jargons used at Pure Biotech Company include: line down, run rate, cycle time, takt time, downtime, changeover, among others.

Language function in Pure Biotech Company, Makurdi

Language generally functions to pass information from one person to another. According to Nweke (2022), in industrial production, language performs, instructional, regulatory and informational functions. Similarly, at Pure Biotech Company, Makurdi, language communicate and inform workers on safety, instructional use of machineries, regulatory information, among other things.

• **Safety communication:** Through the use of language, workers at the company comply to safety instructions to prevent accidents. By this, safety devices are used as a result of the safety tips to workers. Phrases and symbols are used to convey meaning. Consider the following:

Highly inflammable
Radiation
Fire extinguisher
Danger

As seen above, the safety language used in the company is predominantly phrasal in nature with minimal details. That is, it is just straight to the point with minimum or no details.

• **Instructional use of equipments:** the company makes operational manuals available to operators. Apart from manuals, instructions are given to workers at the company to ensure a smooth production. Consider the following examples:

Safety gear (helmet, gloves, and boots) required
Prohibited action or entry
High voltage or electric hazard.

In the company, the above symbols are inscribed on machines/and walls without providing details in words form.

• **Regulatory information:** The machines communicate codes of normality and abnormality to its operators. At the Pure Biotech Company, blue button indicates normal or stable operation; red button indicates abnormal or dangerous operation. Some of these regulatory inscriptions are shown below:

Biohazard
Toxic material
Chemical use or laboratory area
Temperature sensitive item

Language interconnectivity in Pure Biotech Company

In social organizations like the school, staff communicates to one another to ensure a smooth running of the school with each other, communications between a senior staff and his/her subordinate. That is, there is a similar situation with a production company like Pure Biotech Company, Makurdi. According to Uzochukwu and Akor (2021), language interconnectivity in industrial production can occur between human-to-machine, machine-to-machine, vertically or horizontally. These interconnectivity of language are discussed here in relation to Pure Biotech Company, Makurdi.

• **Human-to-Machine/Machine-Human connectivity:** operators of machines at the company input commands and the machines respond accordingly. Machines also communicate to the operators. The command could be power-on, accelerate and power-off commands. Some of the communication inscriptions are shown below:

Recycle or repeat process.
Processing delay or waiting time.
Flow or direction of production.
Packing required or completed.

• **Machine-to-machine connectivity:** Machines communicate to each other during the process of production. For instance, at Pure Biotech Company, after a particular process in one machine is completed, the cassava products are sent to another machine for continuity of production. Sometimes, a machine communicates to another by exchange of data through automated system. This is where a particular machine's malfunction may trigger shutdown of another.

Some of these communications are shown below:

* Prohibited action or entry.
* High voltage or electric hazard.
* Approved or passed inspection.
* Defective or failed inspection.

• **Vertical connectivity:** this is a situation where a senior worker communicates directly to a subordinate to carry out specific function(s). In Pure Biotech Company for instance, when a conveyor basin operator instructs the per loader operator to load fresh cassava tubers into the basin, the communication is said to be vertical in nature. Here communication is in the tone of command or directive. It is usually less professional so that subordinates can understand.

• **Horizontal connectivity:** This is a situation where workers on the same line communicate to one another. For instance, if the production manager sends a message to the sales manager, the communication flow is said to be horizontal. Here the language structure is highly professional.

Research Questions

The following research questions guided the study.

1. How does the structure of workplace language (standardized task labels, command formats, signal vocabulary) relate to production line outcomes (error rate, mean time-to-repair, task throughput) at Pure Biotech Company, Makurdi?
2. How do functional role language (clarity of role labels, presence of procedural scripts) and interconnectivity (digital alerts, two-way radios, and HMI messages) jointly influence coordination and operational performance?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance.

1. Greater standardization of language structure is associated with lower error rates and shorter mean time-to-repair on the production line.
2. The positive effect of role-language clarity on operational performance is stronger when interconnectivity is high; interconnectivity moderates the relationship between role-language clarity and performance.

Related Theories

This study employs the use two theories –Shannon and Weaver's Communication model, and System theory by Bertalanffy to establish a theoretical backing.

Shannon and Weaver's Communication model

This model of communication was developed in 1948 by Claude Shannon and Warren Weaver, (study.com). The model consists of basic elements such as source, encoder, medium, decoder, receiver and noise. It explains how messages are transmitted through a sender-medium-receiver channel. In Pure Biotech Company, Makurdi, the language structure involves human operations, machines, sensors and control systems. Hence the link of the theory.

System Theory (1968)

The system theory is based on the work of a biologist, Ludwig Von Bertalanffy, (Behera, 2024). According to Behera, the theory focuses on the organization as a whole, its interaction with the environment and its need to achieve equilibrium. That is, the theory involves input (physical, human), transformation (worker's activity) and output (product and services). Relatedly, Heil (2023) holds that system theory posits that all parts of an organization are interconnected and influence one another.

In a production line like Pure Bio-Tech Company, Makurdi, communication channels function as subsystems to one another in order to enhance efficiency of production. This shows the link of the theory with the study.

Research Method

Explanatory mixed-methods case study was used. Quantitative survey and performance metrics test hypotheses; qualitative interviews and observational data explain mechanisms and contextualize statistical relationships. The study was carried out at Pure Biotech Company, Makurdi — a fermentation and formulation facility producing laboratory reagents and small-batch bio-products. The production line observed is continuous batching with three daily shifts.

Participants of the sample were operators and technicians (N = 82) - all full-time line staff invited; 76 completed surveys valid for analysis (92.7% response). Supervisors and managers (n = 10) - purposive sample for interviews. Observational sample: 30 hours of systematic ethnographic observation across three shifts (10 hours per shift). Data was collected through structured questionnaire (operators/technicians). Instrument sections: demographic/work history; language practices and preferences (e.g., frequency of standardized terms, perceived clarity); role clarity scale (adapted from Rizzo et al., role ambiguity items); communication technology usage (radios, HMIs, logs); and perceived outcomes (self-reported errors, near misses). Likert scales (1–5) used. Instrument piloted with 10 non-study technicians and refined.

On production metrics, the company performance logs provided: recorded line error events (defects requiring rework), mean time to repair/resolve (MTTR) for machine/process faults, and throughput (units/hour) for the study period (3 months covering the study).

Semi-structured interviews were conducted and supervisors and managers asked about: naming conventions, role scripts, onboarding communication training, the design/use of alerts and connectivity, and examples of communication successes/failures. Interviews lasted 35–60 minutes, audio recorded and transcribed.

Observations and interaction mapping was done. It focused on turn-taking, signal forms (verbal, gestural, device alerts), and sequences during faults and handovers. Field notes and short video snippets (with participants' consent) were used to code interaction patterns.

The study use quantitative analysis. Descriptive statistics of survey items and performance metrics were used. Reliability testing: Cronbach's alpha for multi-item scales (role clarity, language standardization perception). Pearson correlations was used to explore relationships among language structure score, role clarity, interconnectivity index, and performance metrics.

Multiple linear regression models was used for: (a) predicting error rate by language structure and controls (experience, shift), (b) predicting MTTR with language structure, role clarity, interconnectivity, and an interaction term (role clarity × interconnectivity) to test moderation. Statistical significance set at $p < .05$. Analyses run in SPSS/R

Qualitative analysis.

Thematic analysis of interview transcripts and observation notes following Braun & Clarke (2006) steps: coding, theme development, and refinement. NVivo used to organize codes related to naming conventions, repair talk, training gaps, and device-mediated alerts. Triangulation across interviews, observations, and quantitative indices provided convergent validation.

Results

Quantitative findings.

Reliability: role clarity $\alpha = .82$; language structure perception $\alpha = .79$.

Descriptives: mean language-structure score = 3.6 (SD = 0.8); mean role clarity = 3.8 (SD = 0.7); interconnectivity index (composite of radio use, HMI alerts, digital logs) mean = 2.9 (SD = 1.0). Correlations: language structure correlated negatively with recorded error rate ($r = -.42$, $p < .001$); role clarity correlated negatively with MTTR ($r = -.36$, $p = .002$). Interconnectivity correlated positively with throughput ($r = .31$, $p = .006$).

Regression (Error rate): language structure significantly predicted lower error rates (β = −.39, $p < .001$) controlling for operator experience and shift. Model $R^2 = .24$. Regression (MTTR moderation model): role clarity significantly predicted shorter MTTR (β = −.30, $p = .004$). Interaction role clarity × interconnectivity was significant (β = −.18, $p = .03$), indicating that role clarity had a stronger effect on MTTR when interconnectivity was higher. Model $R^2 = .29$.

Qualitative findings

Economy of talk and standardized tokens. Operators favored short tokens ("hold", "flush", "line-stop A") but reported that new hires struggled when multiple variants existed. Observations showed that token ambiguity led to hesitancy and supervisory clarification.

Procedural scripts vs. tacit knowledge. Supervisors emphasized documented scripts for start/stop but admitted many troubleshooting moves are tacit and transmitted orally during shifts; this increased repair time when the experienced worker was absent.

Device-language mismatch. HMIs and digital alerts often use technical labels unfamiliar to operators (e.g., sensor IDs rather than plain language problem descriptors), producing momentary confusion until supervisors interpreted the alert.

Connectivity enabling rapid escalation. Where two-way radio protocols existed and were used consistently, fault notifications reached maintenance faster, shortening MTTR. Where radios were absent or used informally, delays occurred.

Synthesis. Quantitative and qualitative data converge: structured, standardized language reduces errors and speeds repairs; however, the benefits are contingent on interconnectivity design and the alignment of machine/system labels with human language.

Interpretation and discussion

The study demonstrates that language structure (standardized terms and shared signals) functions as an operational tool: it codifies expectations and reduces interpretive work during critical moments, consistent with workplace language socialization findings.

Functional role language clarifies who does what and when. Where role labels and procedural scripts were clear, coordination improved and MTTR decreased. However, where role knowledge was tacit and localized, absence of key personnel produced performance dips.

Interconnectivity acts as a multiplier. Good connectivity magnifies the benefits of clear language by rapidly disseminating well-formed signals; poor connectivity undermines even good linguistic practices by introducing latency and mismatch between machine messages and human vocabularies. This echoes broader observations about human-centered Industry 4.0 implementations: technology must be aligned to human communicative practices.

Practical note. Many manufacturing communication failures stem not from a single factor but from mismatches: e.g., HMIs using sensor IDs while operators expect action-oriented tokens. Training alone cannot fix this unless labels and interfaces are redesigned to reflect on-floor language conventions.

Conclusion and Recommendations

Standardized language structure reduces errors. Role clarity improves repair/coordination, amplified by connectivity. Interconnectivity is necessary but not sufficient. Technical connectivity must be designed with human language practices in mind to realize performance gains. The integration of the industrial production line language structure into teaching and learning could enhance students' performance. This could be in language of technical and vocational education programmes. This would enhance teamwork and improve communication skills, and other language skills' proficiency.

Based on the research conducted, the following recommendations were made:

1. Standardize and document on-floor language:
   a. Create a short "line lexicon" (≤ 2 pages) containing standardized tokens for common commands, fault types, and status reports; distribute laminated copies at work stations and embed them in SOPs;
   b. Use plain-language labels on HMIs and alerts (e.g., "Pump A overpressure — stop pump; call maintenance") rather than cryptic sensor Ids.

2. Align technology labels and interfaces to worker language. Review HMI label conventions with operators; adopt bilingual or action-oriented messages where useful. Involve operators in label design workshops.

3. Strengthen role scripts and cross-training. Codify short procedural scripts for frequent troubleshooting steps and provide brief hands-on workshops (micro-learning) so tacit knowledge is partly externalized.

4. Multilingual glossary should be developed and displayed within the factory's premises for easy communication, hence the use of Chinese language at the company.

5. Language training programmes should be organized to improve workers' communication efficiency.

References

Adewale, T. & Onumanyi, A. (2022). Language, Symbols and Machine Interaction in Industrial Workplaces. *Journal of Semantic Applications*, 9(1), 66-79 Behera, A.K. (2024). System Theory. Retrieved June 24, 2025 from slideshare.net

Bertalanffy, L.V. (1968). General System Theory. Foundations, Development. New York: George Braziller, Retrieved June 28, 2025. From https://www.scrip.org

Bhatia, V. K. (2019). Critical Genre Analysis: Investigating Inter-discursive Performance in Professional Practice. Retrieved 27th June, 2025 from study.com

Chomsky, N. (2006). *Language and Mind* (3rd ed.). Cambridge. Cambridge University Press

Heil, A. (2023). System Theory. Retrieved June 24, 2025 from https://www.sive.edu

Nweke, E. (2022). Language Structures in Industrial Systems: A Semantic Approach. *Journal of Industrial Communication*, 11(2), 45-58

Odozi, I. (2022). Language use in Nigeria Industrial Workspace: A Pragmatic Survey. *Nigerian Journal of Applied Linguistics,* 13(2), 74-85

Pure Biotech Training Manual (2023): Standard Operating Procedures. Internal Company Documents

Sapir, E. (1921). *Language: An Introduction to the Study of Speech.* Harcourt: Brace.

Uzochukwu, I. & Akor, M. (2021). Industrial Communication in Modern Nigerian Factories. *Nigerian Journal of Technical Education,* 18(2), 45-58

Fiset, J., Bhave, D., Jha, N., et al. (2023). *The effects of language-related misunderstanding at work. Journal of Management*. DOI: 10.1177/01492063231181651

Dale-Olsen, H., & Finseraas, H. (2020). *Linguistic diversity and workplace productivity. Labour Economics*, 64, 101813

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101

Ciccarelli, M., et al. (2023). Exploring how new industrial paradigms affect the workforce. *Journal of Manufacturing Systems*

Gedara, M. (2024). Exploring Human Centered Impacts of Integrating Industry 4.0 Technologies with Lean Methodologies (Masters Dessertation)

Katz, M. L. (2001). Engineering a Hotel Family: Language Ideology, Discourse. *Journal of Sociolinguistics.*

Reiman, A., et al. (2024). Human work in the shift to Industry 4.0: a roadmap. *International Journal of Production Research.*