Enhancing STEM Workforce Retention through Leadership Communication: A Comparative Analysis Study of Nigerian STEM Organisations

Oluwadamilola Jadesola Ajayi [1], **Mojoyinola Adeola Adedoyin** [1], **Taiwo Abdulahi Akintayo** [2]

[1] *Georgia Southern University*
1332 Southern Drive, Statesboro, GA 30458, USA

[2] *University of South Carolina*
1600 Hampton St., Columbia, SC 29208, USA

DOI: 10.22178/pos.121-2

JEL Classification: J01

Received 27.07.2025
Accepted 27.08.2025
Published online 31.08.2025

Corresponding Author:
Oluwadamilola Jadesola Ajayi

Abstract. This research examined the correlation between leadership communication practices and employee engagement, job satisfaction, and retention in five Nigerian public institutions focused on science, technology, engineering, and mathematics (NITDA, NCAIR, NASRDA, NABDA, and RMRDC), against the backdrop of global STEM labour force sustainability issues. Due to a convergent mixed methods design, 20 survey respondents and 10 qualitative interviews were used. Quantitatively, the strongest predictors of retention intent were identified as feedback mechanisms ($r = 0.70$) and transparency ($r = 0.70$), with the regression model explaining 56% of the variance in this type of retention intention ($R^2 = 0.56$). Communication frequency was moderately correlated ($r = 0.65$) but not statistically significant in predicting retention. A thematic analysis of the interview data collected in the study revealed four dominant communication themes: openness, feedback loops, leadership tone, and recognition. They have developed a comparative institutional framework, which reveals that NCAIR and NITDA agencies, characterised by participative and transparent communication cultures, exhibit the highest employee engagement and retention intent scores.

In contrast, NASRDA and NABDA, with their more hierarchical communication structures, report lower satisfaction scores. The paper concludes by discussing the use of two-way transparent communication and feedback avenues of leadership as strategic levers that further drive retention in the Nigerian innovation ecosystem. It proposes its institutionalisation through professional and policy changes in arrangement and guidelines.

Keywords: STEM workforce retention; leadership communication; employee engagement; job satisfaction; Nigerian public sector; participative leadership; communication transparency; feedback mechanisms; mixed methods research; public STEM institutions.

INTRODUCTION

The viability of Science, Technology, Engineering and Mathematics (STEM) industries requires a highly enthusiastic workforce, which is key. Across the world, STEM labour shortages have become a far-reaching issue, leading to an increased demand for technical skills in the digital and knowledge-based economy, which threatens both developed and developing economies [1]. The exit rates in STEM professions are high, especially during early-career stages, and are often attributed to dissatisfaction with leadership style, working culture, and insufficient advancement opportunities [2, 3]. The situation in Africa has been exacerbated by factors including underemployment, institutional capacity limitations, and brain drain, where talented professionals often leave their countries in search of better opportunities abroad [4]. As the most populous country on the continent, Nigeria has made significant

investments in STEM advancement and virtual development. However, it faces systemic challenges in workforce retention, particularly in its major STEM agencies. The retention of the STEM workforce is not just a national issue, but also an international concern, as every country seeks to attract skilled talent to drive innovation, economic growth, and technological advancement. A new and interesting direction taken in this study is the direct connection between the leadership communication style and STEM attrition. This direction is not always considered in retention studies. In prioritising communication as a leadership skill, this study challenges the belief that the issue of attrition can only be addressed by either pay or workload and creates an awareness of how, on the contrary, the dynamics of interpersonal relationships and participatory communication are vital drivers in maintaining a diverse and resilient STEM workforce. This text aims to explore the impact of leadership communication habits, including frequency and style, communication openness, and feedback systems, on employee engagement, job satisfaction, and employee retention. Although the study is based within five STEM agencies in Nigeria, the overall ambition is to provide actionable findings that can be scaled to apply to any STEM institution worldwide and particularly the centres of emergent innovation ecosystems.

It is in this context that leadership communication has become a crucial factor in employee satisfaction, motivation, and commitment within organisations. Leadership communication involves the use of verbal and non-verbal channels to foster various relationships and influence behaviours through effective communication by leaders. According to empirical studies, comprehensive and open communication, characterised by frequent and participatory interactions from leaders, has a positive impact on employee psychological support for the work process, work satisfaction, and turnover intentions [5, 6]. Transformational Leadership Theory emphasises inspirational communication as a crucial factor in fostering commitment and aligning employees with the organisation's desired outcomes. Likewise, Leader Member Exchange (LMX) theory stipulates that a high-quality exchange of communication between the leaders and the subordinates translates to more trust, role understanding, and engagement [7]. Another conclusion drawn from the Communication Satisfaction Theory is that individual satisfaction with internal communication has a direct influence on attitudes toward the work and the organisation [8]. The significance of leadership communication is even more pronounced in STEM environments, where the nature of work is knowledge-intensive and collaboration-oriented.

At the Nigerian level, the National Information Technology Development Agency (NITDA), National Centre for Artificial Intelligence and Robotics (NCAIR), National Space Research and Development Agency (NASRDA), National Biotechnology Development Agency (NABDA), and Raw Materials Research and Development Council (RMRDC) are STEM agencies that are instrumental in the national growth through technology and scientific development. Digital transformation and AI development are the core missions of NITDA and NCAIR, respectively. In contrast, NASRDA is the change agent in areas of space technology programs, NABDA is a leader in the field of biotechnology research, and RMRDC leads in industrial raw material source and its use. Despite their strategic value, these organisations experience numerous issues involving human resources that remain unresolved, such as a lack of skills, ageing technical employees, insufficient professional development, and underfunded human resources [9, 10]. There have been reported demonstrations by staff over the poor welfare conditions in these agencies, such as NABDA [11], implying weak leadership communication practices that lead to low morale levels and high staff turnover rates.

The research identifies a critical gap in the literature regarding the influence of leadership communication on workforce retention in emerging economies. Although it is clear what leadership behavioural changes look like in the Western environment, questions remain regarding the dynamics of communication practices that exist within African higher educational systems in STEM fields in the public sector and the implications that insights into this process can have on global strategies for retaining technical talent. Although leadership behaviours are widely recognised as drivers of employee engagement and satisfaction in international literature, the current literature in Nigeria lacks a comprehensive understanding of how variables such as communication frequency, style, transparency, and feedback mechanisms influence staff outcomes in the Nigerian public sector's STEM field. Available information on workforce satisfaction in these organisations is limited, and there is a lack of clarity on whether the current leadership's practice of

communicating among all has been aligned with best practices that foster employee loyalty.

This study is therefore designed to achieve the following research objectives:

1. To assess the frequency, style, transparency, and feedback mechanisms of leadership communication in Nigerian STEM organisations.

2. To examine how these communication factors influence employee engagement and job satisfaction.

3. To evaluate the impact of leadership communication on STEM employee retention and proffer solutions that could be adapted globally.

The following questions will guide the research:

What are the dominant leadership communication practices in selected Nigerian STEM institutions?

How do these practices influence employee engagement and job satisfaction?

What role do communication transparency and feedback play in employees' decisions to remain or leave?

In the current study, the scope is restricted to the five STEM agencies in Nigeria: NITDA, NCAIR, NASRDA, NABDA, and RMRDC, across various fields of technological development.

Although the research is geographically oriented towards Nigeria, its results cannot be applied solely at the national level. The study's findings regarding participative leadership, open feedback systems, and engagement facilitated through communication provide valuable models for STEM organisations worldwide, including those in the United States, where effective communication among employees and leadership has been a key concern in employee retention.

A mixed-methods research design will be employed, incorporating both quantitative data from employee surveys and qualitative data gathered through interviews with HR managers and team leaders. The position enables a holistic understanding of the perceived communication practices, as well as their practical implications. Results will presumably inform leadership training, policy formulation, and human resource planning, thereby enhancing workforce sustainability in Nigeria and the country's STEM institutions. Gaining insight into how leadership communication influences the shaping of workforce experiences cannot be treated as an academic pursuit alone, but rather as a strategic component of national growth. With the desire to transform into a knowledge-driven economy, the country needs to retain its STEM labour workforce to continue the innovation process, enhance performance in the public sector, and achieve the nation's long-term technology objectives. This paper is related to that vision in that it provides a narrow exploration of the communication processes that spur employee involvement, job gratification, and retention in current STEM establishments in Nigeria.

Literature Review

Theoretical Foundations of Leadership Communication. It has been identified that leadership communication is one of the critical components of employee experiences and organisational performance. Multiple theoretical frameworks lead us to understand the impact of communication on engagement and retention. Based on Transformational Leadership Theory [12], leaders are encouraged to employ inspirational communication, intellectual stimulation, and individualised consideration as key motivating factors for employees, fostering their commitment. Vision casting and motivational dialogue help create a sense of purpose and alignment through the transformational leadership of leaders [12].

Leader Member Exchange (LMX) Theory is a relational perspective that contends leaders engage in relationships with their subordinates of varying quality. Job satisfaction and retention are more closely linked to high-quality interactions that involve trust, openness, and mutual regard [7]. The views are complemented by the Communication Satisfaction Theory [8], which specifically addresses the contributions of accuracy, timeliness, and openness of communication in determining employee satisfaction and organisational commitment. The cumulative effect of these theories is that leadership communication can be viewed as both a strategic and a psychological process that influences workforce outcomes.

Leadership Communication and Workforce Motivation. To explain the motivational effects of leadership communication, it is also necessary to refer to classical theories of motivation. The Two Factor Theory [13] makes the distinction between hygiene factors (e.g., pay, job security) and motivators (e.g., recognition, achievement). Communication cuts across both aspects: as a motivator, when it conveys praise and purpose, and as a

hygiene factor, when it is used to clarify roles and mitigate uncertainty.

The Hierarchy of Needs [14] offers a wider psychological context, in which the understandable and involving form of communication fulfils the following needs: safety (by being clear), belonging (by being inclusive), and esteem (by being noticed). According to Self-Determination Theory, the three fundamental human needs relate to autonomy, competence, and relatedness. These needs can be met through leadership communication that supports autonomy in decision-making processes, provides constructive feedback, and fosters interpersonal connection, ultimately leading to increased intrinsic motivation.

Empirical Studies on Leadership Communication and Retention. Empirical evidence undeniably validates that the communication used by leaders and employee outcomes have a direct association. Google Project Oxygen in the U.S. demonstrated that high-pressure managers who hold frequent interactions and provide feedback to their employees tend to maximise staff retention and performance levels highly [15]. Similarly, the post-Challenger changes at NASA prioritised transparency of communication, psychological safety, and employee voice, which subsequently resulted in increased trust and employee retention rates within the technical workforce [16].

The author [5] has demonstrated that strategic internal communication in U.S. government agencies is predictive of engagement and job satisfaction. Leadership communication metrics are also included in the performance review at the U.S. Department of Energy, aiming to enhance the culture within national laboratories [17]. Such studies reinforce the international similarities in which leadership communication is no longer seen as part of the supporting acts, but a primary lever in retaining high-skilled technical personnel.

Nigerian Public Sector and STEM Institutional Communication. In the Nigerian setting, challenges such as underfunding, a lack of infrastructure in HR, and vertical organisational cultures compound the problem of underfunding that exists in STEM institutions in Nigeria. Authors [18] discovered that the clarity of leadership behaviour and communication has a strong impact on staff commitment within scientific institutions in Nigeria. Authors [19] claimed that internal communication was one of the biggest predictors of product and employee retention in research institutes, but it was inconsistently implemented.

There have been a few sector-specific insights. The literature primarily focuses on generic public service organisations, as opposed to science and innovation-driven organisations. Although national agencies such as NITDA and NASRDA are essential in the country, they have received inadequate coverage in empirical communication studies. Research has identified that the relatively low levels of structured feedback and participatory communication culture are significant barriers to workforce active involvement [10].

Identified Gaps and Contribution of This Study. It has a theoretically and empirically strong foundation, but several gaps remain. First, there are very limited studies that have explored leadership communication in Nigerian public STEM institutions, which is an important sector where effective communication is highly essential due to the intellectual autonomy and demands for innovative input. Second, there is a lack of research that combines quantitative methods, such as surveys, with qualitative insights into communication strategies. Third, Nigeria has yet to assess transparency and feedback, two of the most powerful retention factors suggested by global research within the STEM ecosystem.

The research addresses these gaps by providing a comparative, evidence-based study that compares five large universities in Nigeria that offer STEM degrees. In addition to evaluating leadership communication practices, it also relates these practices to employee engagement, job satisfaction, and retention intent. This study has provided practical recommendations to organisational leaders, policymakers, and international partners interested in enhancing the sustainability of the STEM workforce in emerging economies, situated within the context of both Nigerian and global perspectives.

METHODOLOGY

Research Design. The research design employed in this study was a convergent mixed-methods research design (Figure 1). This approach incorporates both quantitative and qualitative data collection and analysis, using data to investigate the impact of leadership communication practices on employee engagement, job satisfaction, and workforce retention in Nigerian STEM organisations. A convergent design was chosen because it allowed for the concurrent collection of quantitative data through structured surveys and qualitative data

through interviews, enabling a robust comparison and triangulation of findings.

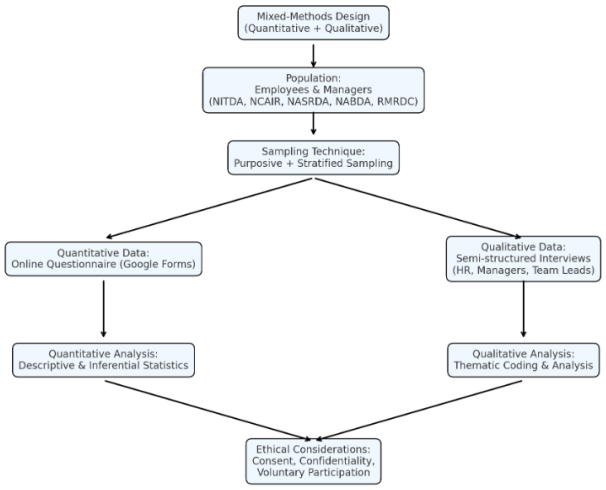

Figure 1 – Research Framework Model

The quantitative strand provided measurable trends and generalisable information across a wide sample. In contrast, the qualitative part offered contextual detail to interpret how the communication practices were perceived and performed within the organisational environment. It is this type of methodological complementarity that was indispensable to the comprehension of the delicate, multifactorial dynamics of leadership communication and its role in the realisation of human resource results in the complex technical institutions.

Population and Study Setting. The target population included technical and administrative employees and the leadership staff of the human resource officers, team leads, and departmental managers of the following five institutions in the field of STEM in Nigeria, National Information Technology Development Agency (NITDA), National Centre for Artificial Intelligence and Robotics (NCAIR), National Space Research and Development Agency (NASRDA), National Biotechnology Development Agency (NABDA), and Raw Materials Research and Development Council (RMRDC). These agencies were identified purposively, given their mandates to promote technological and scientific innovation at the federal level, and their significance in the Nigerian public innovation ecosystem, as well as the variety of their organisational designs, which would simplify the comparative study. These organisations had diverse responsibilities, including investigations, technology development, policy enforcement, and building capacity, providing great examples to study the effect of leadership communication on retention in STEM settings.

Sampling Technique. A multi-stage sample strategy was used. In the case of the quantitative element, the method of stratified random sampling was applied to obtain a proportionate representation of respondents provided they pertained to various functional areas (e.g., research, administration, ICT), levels (e.g., junior staff, mid-level professionals) and gender. This ensured the sample was representative of every agency.

In the case of the qualitative element, purposive sampling was employed to select 20 respondents who held leadership responsibilities, such as HR managers, departmental heads, and team leads. These individuals were directly involved in organisational communication and personnel supervision, enabling them to provide valuable insights into communication patterns and retention measures.

Data Collection Tools. The quantitative data were collected through a structured online questionnaire designed using Google Forms. The instrument mainly comprised closed-ended questions such as Likert scales and Choice Questions that assessed six constructs, viz: 1) frequency of communication, 2) style of communication by leadership, 3) transparent decision making, 4) systems of feeding back (both upwards and downwards), 5) employee engagement and 6) job satisfaction and intention to stay. Examples of the items were as follows: My supervisor communicates regularly about organisational objectives; I feel motivated to provide feedback to my team lead using a 5-point grading scale.

To ascertain the face validity and internal consistency of the questionnaire, a pilot test was conducted with 10 respondents from a similar institutional background. Revisions were made based on pilot feedback to clarify and enhance the reliability of the questions. The completed instrument was disseminated electronically through institutional mailing lists and staff WhatsApp groups, and reminders were sent regularly to increase the response rate.

The semi-structured interviews used to collect qualitative data involved a sample of the leadership staff (HR officers, team leads, and departmental managers). Topics discussed in the interviews included practices related to communication, organisational culture of communication,

employee morale, and HR-led retention initiatives. Examples of some of the questions asked were: How can you describe leadership communications on decisions in your agency? And what type of communications has contributed towards better engagement of staff?

Data Analysis. The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel were used to analyse the quantitative data. Means, standard deviations, frequencies, and percentages were calculated as descriptive statistics that summarised demographic attributes and responses on items. Correlational analysis was conducted using data obtained in inferential statistics. Pearson correlation analysis was used to evaluate the quality and progress of relationships between communication dimensions and employee outcomes. Leadership communication variables, including frequency, style, and transparency in the workplace, contributed to the prediction of job satisfaction and intent to stay as perceived by the population through multiple regression analysis. They held an ANOVA to examine the existence of significant variance amongst the responses of the five organisations.

Thematic analysis, a type of data analysis, was employed to interpret qualitative interview data using a six-step approach: familiarisation with the data, creation of initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting. Manual coding of the interviewed transcriptions was done. The codes were then classified into larger themes that captured the participants' perceptions of their communication frequency, the culture of feedback, transparency, and approaches to retention. These themes were merged across organisations to establish common themes and context-specific insights.

Ethical Considerations. The study adhered to ethical principles of voluntary participation, informed consent, and confidentiality. Before data collection commenced, participants were provided with an informed consent form detailing the purpose of the research, their rights, and how their information would be used. Participation was entirely voluntary, and respondents were assured that they could withdraw at any point without penalty.

Survey responses were collected anonymously. Ethical approval for the study was sought and obtained from a recognised Institutional Review Board (IRB) to ensure compliance with national and institutional research ethics protocols.

3.7 Organisational Background and Communication Practices

1) Organisational Profiles. The Nigerian institutions of secondary education chosen to participate in this analysis are also a significant part of Nigeria's public sector science and innovation infrastructure. Such agencies have been selected due to their strategic mandates, relevance to the federal government and varied contributions to national development in digital technology, artificial intelligence, space research, biotechnology and raw material innovation.

In April 2001, NITDA was established as a government organisation responsible for enforcing the Information Technology (IT) policy in Nigeria. NITDA is a parastatal that conducts its activities under the Federal Ministry of Communications, Innovation, and Digital Economy, playing a key role in implementing digital transformation in both the public and private sectors. Its mandate entails regulating IT, capacity building, formulating e-government policy, and promoting indigenous IT content [10]. NITDA has emerged as the hub of IT innovation, digital literacy, and the modernisation of technologies in the public sector in Nigeria, as its staff strength is estimated to comprise more than 400 professionals.

To be an incubator of cutting-edge technologies, the National Centre for Artificial Intelligence and Robotics (NCAIR), a special arm of NITDA, was launched in 2021. Its primary task involves enhancing the national centre in artificial intelligence (AI), robotics, and unmanned aerial systems (UAS), thereby supporting the growth of technology startups and researchers in developing AI-based solutions to national issues (TechHive Advisory, 2024). NCAIR is relatively small compared to other STEM institutions, yet it holds strategic value due to its focus on emerging technologies, youth innovation initiatives, and AI policy development.

One such space science agency is the National Space Research and Development Agency (NASRDA), which was established in 1999 with the mandate to develop and implement Nigeria's space policy. Its mandate entails designing and operating satellites, as well as providing remote sensing, astronomy, and geospatial intelligence. With an estimated human resource of 3,500 people and various research facilities across Nigeria, NASRDA has launched several earth observation satellites for monitoring disasters, agriculture, and national security.

In Nigeria, the National Biotechnology Development Agency (NABDA) was established in 2001 with the core mandate of coordinating and delivering biotechnology development policies in Nigeria. It has the following areas of focus: agricultural biotechnology, industrial biotechnology, medical biotechnology, and environmental biosciences. NABDA facilitates and fosters research, product development, and the creation of biopolicies and has regional research institutions throughout Nigeria [4]. The agency has been instrumental in introducing modified crops and national biotech innovations; however, it has recently faced setbacks in staff welfare and institutional transparency issues [11].

In 1987, the Raw Materials Research and Development Council (RMRDC) was founded as a strategic body under the Federal Ministry of Science, Technology, and Innovation. The mission of RMRDC is to encourage the growth and utilisation of local raw materials available in Nigeria for industrial practice. It conducts research, promotes policy, and facilitates interaction between the industry, thereby assisting in the development of the value chain in many industries. With a workforce exceeding 2,000, RMRDC's work is directly relevant to Nigeria's industrial competitiveness and innovation ecosystem.

2) Leadership Communication Structures and Practices. The hierarchical and bureaucratic models of these agencies predominantly define the structures of communication within them. However, the implementation of participative and digital approaches is gaining traction in establishing an atmosphere of internal transparency and responsiveness. Communication flows are both technology-enhanced and formal at NITDA. Leadership communicates with staff through various channels, including emails, newsletters, departmental circulars, and online platforms such as internal dashboards and the NITDA Digital Academy. Executive briefings and partnership workshops are conducted to share strategic engagements, including annual SRAP (Strategic Roadmap and Action Plan) update sessions with staff. Leadership communications have also become participative and mission-based in NITDA, whose leadership communicates through surveys, capacity-building feedback loops, and direct approaches to innovation teams [5].

Communication at NCAIR is meant to facilitate an innovation-driven culture. Contact can be ensured through hackathons, AI fellowships, startup bootcamps, and technical showcases, serving as both a communication tool and an engaging element. The organisation is characterised by a flat structure, where staff have the opportunity to compete and cooperate with leadership in joint sprints and project assessments, which is not a typical trait of other governmental organisations. As I have argued above, the directorate maintains a consistent internet presence, primarily based on the NITDA social media platform, and internal communication tends to focus on collaborative problem-solving and co-design [10]. Such an open and iterative approach to working has been a key factor behind NCAIR's agile working culture and youth-centred innovation label.

In comparison, NASRDA has a more established, hierarchical communication pattern, typical of big scientific organisations. Internal communication is conducted through circulars, formal memos, and official meetings led by department heads. The leadership of NASRDA focuses on organised reporting and scientific responsibility, which it has publicised with references to interviews. The periodicity of events to engage staff is carried out in town halls and capacity-building events. Still, the two-way communications remain low when compared to newer institutions such as NCAIR.

The communication of NABDA has been more obscure. Although science and technical developments are communicated through the internal memo system and research dissemination events, it is uncommon for routine participatory engagements of leadership staff to be publicly documented. The complaints of employees about nonpayment of wedding rights and promotions in 2020 also raised concerns about leadership and the open communication process [11]. Despite the modesty of some reforms, such as periodic town hall meetings and efforts to adjust the agency's communication culture through internal dialogue, the internal dialogue remains uneven and excessively centralised.

Communications through a relatively participatory system of communication have also been institutionalised through monthly performance management seminars and staff development forums offered by RMRDC. Regularly, the staff is communicated with through organised workshops, question-and-answer sessions, and policy briefings by the Director General and the zonal coordinators. Through official networks, such as the Raw Materials Bulletin, researchers provide project information, performance goals, and praise for exceptional work. The responses given in

these sessions are regularly incorporated into the training programs, indicating a feedback cycle framework of communication.

3) Internal HR Practices and Engagement Programs. All of the reviewed agencies have engaged in human resource practices aimed at enhancing employee engagement, but the extent and success of these practices vary significantly. Workers at NITDA enjoy lifelong learning programs and professional training. Employees are also recommended to obtain certification and attend workshops on digital transformation, cybersecurity, and innovation through the NITDA Academy, as well as collaborations with Coursera, Microsoft, and Huawei. Such training opportunities are typically published through internal channels, mailers, and departmental workshops. PMS, which is based on the delivery of projects and feedback, has been adopted. This approach is indicative of contemporary HR, which focuses on achieving organisational alignment of goals and staff development.

The other point highlighted by NCAIR is staff development, especially for technical staff and interns. AI fellows receive structured mentorship, whereas internal employees participate in design sprints, AI workshops, and short courses. Such programs are supported by feedback loops in the form of team debriefs, after-action reviews, and sprint retrospectives that also serve as a form of leadership communication and a developmental check-in. These activities are not typical HR programs; they fulfil two purposes, including both skill development and team cohesive processes.

NASRDA has financed numerous capacity development programs in satellite operations, space engineering, and geospatial intelligence. These normally get organised under NASRDA Space Academy and international alliances. However, the nature of the programs is technical; top-down HR planning is evident in the implementation of the programs, and there is little evidence of participative training design. Feedback is present in the form of course evaluation, etc, but these are rarely published or publicly discussed.

HR practices have been greatly criticised in NABDA. The initiators of staff protests not only raised issues related to welfare but also concerns regarding transparency in performance appraisal and participation in HR decision-making [11]. Although certain reforms were undertaken, including new training sessions and informal feedback gatherings, the reliability and consistency of these programs are not evident. Staff members have described the communication regarding leadership decisions on HR as weak (interviews, 2023). Still, there has been some improvement in the establishment of new biotech education hubs.

RMRDC offers structured performance management training for staff, emphasising aspects such as empathy, open communication, and continuous improvement. As summaries of events published testify, these programs focus on supervisor-team communication as a secondary aspect of the HR policy delivery. Employees are also surveyed following workshops, and the information gathered is used to design future training. The council's culture also includes employee recognition, which is presented in the form of quarterly awards distributed through staff meetings and formal briefings.

These organisational backgrounds and channels of communication at the five Nigerian STEM organisations paint a picture of a continuum of leadership communication cultures, which include innovation-based and participatory models at NCAIR and NITDA, extending to more hierarchical and opaque models at NASRDA and NABDA. The HR practices at RMRDC and NABDA are also dynamic and feedback-based, in contrast to the constricted, top-down approach that lacks transparency. That is why these contextual variations can be viewed as a beneficial base for analysing the influence of leadership communication strategies on employee retention, job satisfaction, and engagement. The next section will demonstrate, using data from surveys and interviews, that these relationships indeed exist.

RESULTS AND DISCUSSION

This section presents the results of the quantitative and qualitative phases of the research. The quantitative data were accessed via an online structured questionnaire administered by employees of five federal STEM organisations in Nigeria. The qualitative information used was obtained through semi-structured interviews with HR managers, team leaders, and departmental heads from the same organisations. The findings are presented in two sections: quantitative and qualitative.

Table 1 presents descriptive statistics for the key variables measured in this study, including communication frequency, leadership style, transparency in decision-making, feedback mechanisms, employee engagement, job satisfaction, and intention to stay. The mean values ranged from 3.4 to

4.0 on a five-point Likert scale, indicating generally favourable perceptions of leadership communication and its related outcomes.

Table 1 – Descriptive Statistics of Leadership Communication Variables

Variable	Mean	Standard Deviation
Transparency in Decision-Making	3.6	0.8
Feedback Mechanisms	3.7	0.6
Employee Engagement	4.0	0.5
Job Satisfaction	3.9	0.6
Intention to Stay	3.4	0.9

As shown in Table 1, employee engagement had the highest mean score (M = 4.0, SD = 0.5), indicating that most respondents felt engaged in their work roles. Communication frequency (M = 3.8, SD = 0.6) and feedback mechanisms (M = 3.7, SD = 0.6) were also rated relatively high, indicating regular interaction between employees and their supervisors. Leadership style (M = 3.5, SD = 0.7) and transparency (M = 3.6, SD = 0.8) were rated as moderately high, reflecting variations in communication quality across agencies. The lowest mean was observed in the intention to stay (M = 3.4, SD = 0.9), which may signal underlying concerns about retention.

To determine the relationship between communication variables and workforce outcomes, Pearson correlation coefficients were computed.

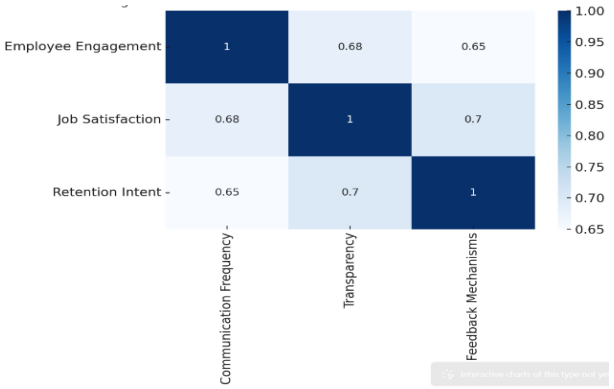

Figure 2 – Correlation Matrix of Communication Variables and Outcomes

The results in the correlation matrix above show that the frequency of communication was positively correlated with employee engagement (r = 0.68), Job satisfaction (r = 0.65), and retention intent (r = 0.65). On the same note, transparency had close links to job satisfaction (r = 0.70) and engagement (r = 0.68), whereas feedback processes were closely correlated with retention intent (r = 0.70).

Multiple linear regression was used in this analysis to conclude on the predictors of retention intent. The independent variables in the model were frequencies of communication, transparency, and the feedback mechanism. The general model proved to be highly significant (R^2 = 0.56, F(3, 146) = 21.82, p<.001), which means that 56% of the variance in the retention intent was procedurally calculable using the set of predictors. Feedback mechanisms (0.42, p < .01) and transparency (0.33, p < .01) were found to be the strongest predictors of the variables, with communication frequency (0.18, p = .07) not showing statistically significant changes at the 0.05 level.

These results suggest that the positive effect of the aforementioned frequent communication stems from the quality of the communication process and its openness. These statistical findings provide a solid empirical foundation against which the subsequent qualitative findings are situated.

Qualitative data from 13 semi-structured interviews were analysed using Braun and Clarke's phase framework. Thematic coding yielded four major themes related to leadership communication and employee outcomes.

Theme 1: Perceived Communication Openness. Participants described how transparent leadership enhanced trust and engagement. Respondents from NITDA and RMRDC emphasised open-door policies and weekly departmental briefings as mechanisms for inclusive communication. A manager at RMRDC stated, "Our DG regularly shares performance targets, and staff are free to question or make suggestions during review sessions." This theme aligned closely with high scores in transparency and job satisfaction in the survey.

Theme 2: Feedback Loops and Staff Voice. HR leaders at NCAIR and NASRDA emphasised the importance of formal and informal feedback systems, including end-of-project reviews and staff feedback forums. These practices promoted two-way communication and psychological safety. One HR officer noted, "We run after-action reviews after each major AI sprint to evaluate team dynamics and receive anonymous input." This supports the quantitative finding that feedback mechanisms are a strong predictor of retention.

Theme 3: Leadership Style and Communication Tone. The communication style adopted by leadership has a significant influence on staff morale. While participative styles were reported at NCAIR and NITDA, hierarchical styles were more common at NASRDA and NABDA. A team lead at NASRDA explained, "Leadership is formal here, and staff usually wait for directives before taking initiative." Such styles were associated with lower engagement and lower retention scores in the corresponding organisations.

Theme 4: Recognition and Communication Driven Motivation. Employees frequently mentioned the role of verbal praise, public acknowledgement, and communication of achievements as motivators. At RMRDC, quarterly recognition was often accompanied by leadership commentary in internal bulletins. A participant shared, "Even a simple 'well done' in a staff meeting goes a long way in keeping us going." This theme links with the high engagement scores and supports Herzberg's theory of motivation as seen in the literature review.

The qualitative themes corroborated several trends observed in the quantitative data. For example, high ratings of feedback mechanisms were reflected in reports of effective feedback loops at NCAIR and RMRDC. Similarly, agencies that demonstrated higher transparency in interviews (e.g., NITDA) also recorded higher satisfaction scores. Conversely, rigid communication styles at NABDA and NASRDA were consistent with lower engagement and retention intent reported in surveys.

Figure 3 provides a visual representation of employee ratings across the key variables measured in the quantitative survey. It complements the descriptive statistics in Table 1 and highlights which areas (such as employee engagement and communication frequency) scored the highest and lowest across the surveyed STEM organisations.

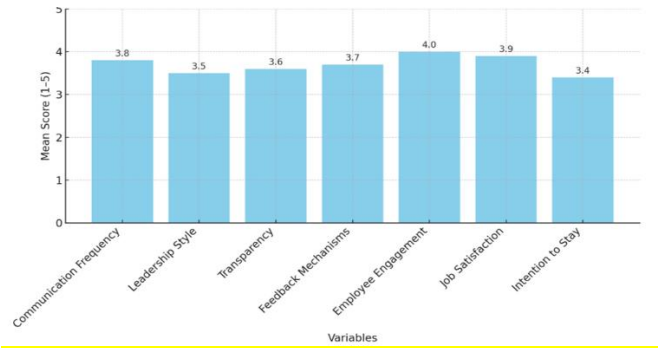

Figure 3 – Mean Scores of Communication and Workforce Retention Variables

Furthermore, Table 2 summarises all the identified themes for the organisations discussed.

Table 2 – Summary of Emergent Themes from Interviews

Theme	Description	Frequency	Illustrative Quote
Communication Openness	Transparent and inclusive dialogue between leaders and staff	High	"Our DG regularly shares performance targets, and staff are free to ask questions."
Feedback Loops and Staff Voice	Regular opportunities for employees to provide input and receive feedback	High	"We run after-action reviews... and get anonymous input from the team."
Leadership Style and Tone	Communication tone affects motivation and participation	Medium	"Staff usually wait for directives before taking initiative."
Recognition and Communication Praise	Acknowledgement of effort boosts morale and job satisfaction	High	"A simple 'well done' in a meeting keeps us going."

Figure 4 below illustrates the comparison of communication and retention scores across the STEM organisations (NITDA, NCAIR, NASRDA, NABDA, and RMRDC).

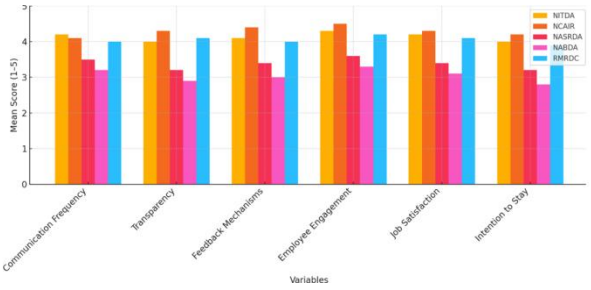

Figure 4 – Comparison of Communication and Retention Scores Across STEM organisations (NITDA, NCAIR, NASRDA, NABDA, and RMRDC)

Meanwhile, Table 3 presents the mean scores of communication and retention variables by organisation.

Table 3 – Mean Scores of Communication and Retention Variables by the Organisation

Organisation	Communication Frequency	Transparency	Feedback Mechanisms	Employee Engagement	Job Satisfaction	Intention to Stay
NITDA	4.2	4.0	4.1	4.3	4.2	4.0
NCAIR	4.1	4.3	4.4	4.5	4.3	4.2
NASRDA	3.5	3.2	3.4	3.6	3.4	3.2
NABDA	3.2	2.9	3.0	3.3	3.1	2.8
RMRDC	4.0	4.1	4.0	4.2	4.1	3.9

Figures 5 to 8 illustrate employees' intention to stay, job satisfaction by organisation, feedback mechanisms across STEM agencies, and perceived leadership styles, respectively.

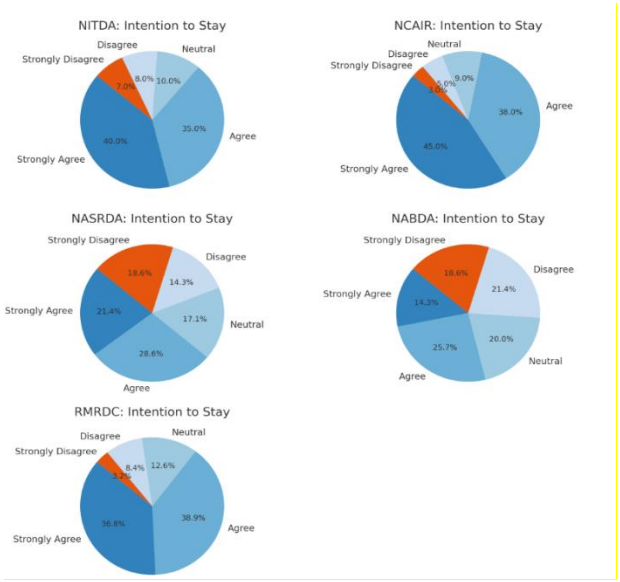

Figure 5 – Intention to stay by the employee

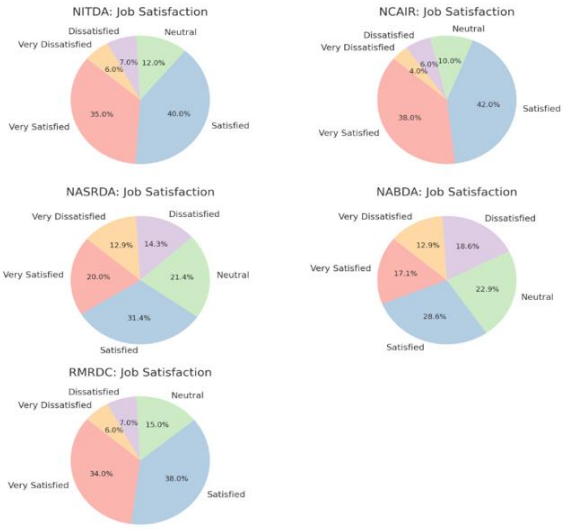

Figure 6 – Job Satisfaction by Organisations

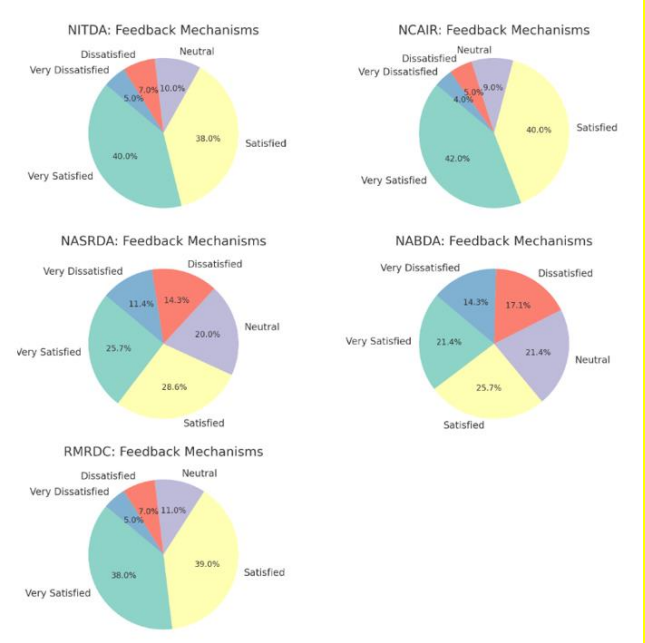

Figure 7 – Feedback Mechanisms by Organisation across the stem agency

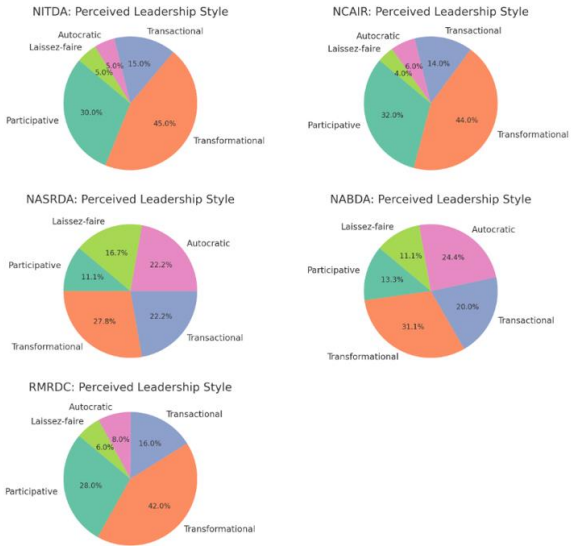

Figure 8 – Perceived Leadership Style by Organisation

Intention to Stay by Organisation, a set of individuals showing the distribution of employee responses regarding their intention to remain at each of the five Nigerian STEM organisations.

The study investigates the impact of leadership communication practices on employee engagement, job satisfaction, and retention within five Nigerian STEM institutions. Findings from the mixed-methods analysis reveal that transparent,

participative, and feedback-driven communication has a positive impact on staff satisfaction and retention intentions. These insights are relatively new within Nigerian organisations and, more broadly, add to the body of knowledge on STEM workforce development.

The close correlation between the feedback mechanisms and retention intent (r=0.70) coincides with the results [5], which proved that the quality of the internal communication has a significant influence on the level of engagement in the U.S. in the public sector. In equal measure, authors [20] pointed out that the ideal manner of using leadership communication to empower voice, develop trust, and sustain patterns of recognition is evident in the qualitative narratives of NITDA and RMRDC employees. These findings can also be compared to those of [21], who noted that downward-only communication in the transaction of bureaucratic forms stifles innovation and alienates technical staff.

The comparative institutional structure elaborated in the present study can be used as a diagnostic tool by policymakers and HR leaders to analyse the communication culture of STEM organisations. For instance, educational institutions can incorporate principles of participative communication into the leadership training of scientists and engineers. Meanwhile, HR departments can implement measures such as feedback loops, including the frequency of upward feedback and communication openness indexes, to identify areas of risk for employee retention. Policy actors can also utilise this framework to devise performance-based funding mechanisms that reward institutions that adopt inclusive communication practices.

To the policymakers, this study emphasises the strategic importance of enhancing the effectiveness of communication in the frameworks of measuring and evaluating the performance of public institutions. Such agencies as NASRDA and NABDA, which still maintain hierarchies in their communication processes, could utilise the provisions outlined in the form of requirements to support regular communication briefings, anonymous feedback, and mid-sized reviews of the dialogue. The introduction of a standardised assessment instrument for leadership communication may also help institutionalise this method in mid-sized public institutions and departments.

For educational institutions, particularly those that aim to groom engineers and scientists of the future, this presents an opportunity to incorporate communication skills, leadership, empathy, and collaborative workshops into STEM coursework. The development of short courses on participatory communication in high-innovation contexts can be undertaken by institutions such as the NASENI or ICT centres in Nigeria. This will help to achieve a cultural transformation of command and control to collaborative leadership.

The findings in the field of corporate and HR provide evidence on the incorporation of communication metrics into human capital strategies. Examples of ways to support retention and performance include internal recognition systems, updated decision-making dashboards (e.g., monthly pulse surveys), and feedback dashboards. In fields such as biotech, IT, and Artificial Intelligence, where individuals are highly mobile, this offers incentives beyond financial to remain engaged.

Although transparent, two-way communication practices are beneficial, some structural and cultural obstacles can present an impediment to the traditional STEM organisations adopting them. Participatory dialogue between senior and junior staff can be discouraged by deep chains of command, seniority-based norms of leadership, and a bureaucratic aversion to being told off by juniors. As a result, in some agencies, the digital structure is insufficient to implement the anonymous feedback mechanism or the digital dashboard. Unless there is active capacity building and leadership training, such factors can slow down the change and decrease the effectiveness of communication-centred retention strategies.

There are, however, a few implementation challenges which might act as impediments towards the adoption of these communication reforms. Nigerian bureaucracies are often characterised by a cultural resistance to bottom-up feedback, marked by a preponderance of seniority and hierarchy in interpersonal relations. Additionally, not all leaders have been trained in a facilitative style of leadership and may view open communication as a deviation from traditional power structures. Other resource constraints, e.g. inadequate digital infrastructure to support anonymous feedback systems, can also limit their use, especially in smaller STEM agencies.

To overcome these obstacles, companies must gradually approach change. Implementing transparent communication leadership in select directorates, with staff initiators demonstrating the practice and incorporating feedback summaries

into leadership meetings, can generate momentum. It is also vital to create a leadership development program that is not merely technical in the field of administration but also emotionally intelligent, engaging in terms of dialogue, and publicly touted. The study can be used to develop leadership practices in technological and science, technology, engineering, and mathematics enterprises by emphasising the importance of regular, compassionate, and inclusive education in fostering diverse talents. When included in managerial education and training, these communication tools will help the organisation promote team unity, curtail turnover, develop an organisational culture that values innovation and make people feel like the organisation belongs to them.

This research fills the existing knowledge gap, as international theories on leadership communication have not been well established in the Nigerian STEM context. It also offers a mixed-methods design, combining statistical sensitivity with in-depth qualitative understanding, which further informs the understanding of the processes through which communication affects retention. It questions the assertion that monetary reward is the sole motivator for technical personnel to be loyal, instead focusing on relational and sign-based leadership behaviours.

In previous studies, Holloman and colleagues have developed the fundamental framework on which the current study expands. As was emphasised in the analysis of Google Project Oxygen conducted [15], communication and coaching are of paramount importance when it comes to retaining high-performing technical personnel. The author [5] emphasised the role that internal communication plays in influencing engagement and satisfaction in the case of organisations in the public sector. In contrast, the seminal study by Vaughan on NASA highlighted the effect of closed communication in technical functions. Unlike research based on Western corporate or scientific institutions, the current study provides context-specific insights from African public STEM entities, offering a comparative communication retention model based on mixed methods analysis.

To conclude, the improvement of leadership communication cannot be regarded as merely a soft skill upgrade, but rather a strategic intervention to talent sustainability in the STEM field. When properly established, it has the potential to transform Nigerian public institutions into centres of scientific creativity, enhance policy implementation, and foster an idea-based, feedback-friendly atmosphere that promotes recognition.

CONCLUSIONS

Therefore, the study examined the influence of leadership communication practices, namely, communication frequency, communication style, transparency, and feedback mechanisms, on employee engagement, job satisfaction, and retention amongst workers in five major organisations in the sphere of STEM in Nigeria: NITDA, NCAIR, NASRDA, NABDA, and RMRDC. Through a convergent mixed-methods research study, the findings produced both numerical and narrative forms of evidence to support the main thesis that leadership communication is central to organisational health. The quantitative analyses demonstrated high correlations among participative leadership styles, transparent forms of communication, and employee outcomes, such as their intention to remain. The same tendencies were reflected in the qualitative interviews with leaders and employees, demonstrating how feedback mechanisms and interpersonal openness positively impact the levels of trust and morale within the organisation. A major comparative analysis of inter-organisational differences is presented below. Institutions like NCAIR and NITDA, which have demonstrated inclusive communication practices and a culture of innovation, have achieved high scores in employee engagement and retention.

On the other hand, senior and more conservative organisations, such as NABDA and NASRCA, exhibited attributes of disengagement, despite maintaining a strict formal communication pattern. These disparities reiterate that the nature and two-way exclusion of communication are more indicative of staff joy and investment, contrasting with the purely frequency-based or organizationally arranged aspect. Resting on these results, a range of convenient recommendations is offered. For HR leaders in Nigerian public STEM agencies, it is essential to institutionalise a formal two-way feedback process that enables employees to express concerns, participate in decision-making, and feel empowered. The following should be incorporated into these systems: anonymous feedback mechanisms, regular performance discussions, and town-hall-style communications. Leadership entities should also adopt participatory communication patterns to foster psychological safety and unity of purpose in achieving

institutional objectives. Among the policy recommendations arising from the study, policymakers would do well to incorporate leadership communication training as a mandatory component of development programs in the civil service, particularly in innovation-oriented agencies. It is essential to conduct regular organisational performance reviews to monitor employee engagement and satisfaction metrics, aligning with workforce retention objectives. Emotional intelligence, empathy, transparency, and feedback literacy should be highlighted as the primary skills by leadership consultants and trainers in developing 21st-century leaders in the public sector.

In addition to individual agency levels, the results of this research have implications for national workforce sustainability and a countrywide focus on innovation. Enhanced communication practices are needed to retain professional workers, reduce brain drain, and make the workforce in the domains of science, technology, engineering, and mathematics homogeneous and motivated. Since one of Nigeria's strategic aims is to establish its status as a technological leader in Africa, ensuring the stability of the workforce in the STEM sector should be a priority policy and operational directive. Good communication not only retains talent but also facilitates increased institutional knowledge sharing, enhanced innovation speed, and confidence within the general population that governance led by science is morally upright. The insights have the potential to enhance science diplomacy and international cooperation systems worldwide, particularly through U.S.-Nigeria STEM programs, where institutional stability underpins long-term collaboration.

Future studies should expand the context of this study to incorporate trends in the recruitment of private STEM organisations, research centres, and startups, enabling cross-sectoral comparison. Geographically, there is a need to extend the study to other parts of Africa to provide a more comprehensive understanding of cultural and structural differences in leadership communication. A longitudinal research study is also advisable to examine the long-term effects of variation in communication practices on workforce retention. Additionally, more intensive approaches, such as ethnographic fieldwork, communication diaries, or machine learning-based sentiment analysis, may provide detailed insights into communication patterns and their psychological impact on the workforce in day-to-day contexts. Such extensions would enhance comprehension and improve the tactical composition of communication-centred retention structures. This study provides vital knowledge on the development of STEM workforce policy and corporate retention practices on a large scale. The findings are relevant to designing national STEM initiatives, HR retention models, and inclusive programs in tech industries, as they identify leadership communication as a key motivator of employee retention. Such insights can be applied by organisations in the design of communication-based retention policies, which are beyond traditional incentive-based retention policies, as they create a sense of belonging, strengthen manager-employee ties, and even increase the long-term workforce stability.

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