Bridging TVET Education and Cleanroom Industry Expectations: An AI-Supported Behavioural Alignment Framework for SOP-Oriented Workforce Readiness

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Abstract. This study proposes a cross-institutional AI-supported behavioural communication framework designed to align Technical and Vocational Education and Training (TVET) classroom communication practices with cleanroom-regulated industry expectations. Cleanroom environments, which are commonly viewed as technical engineering systems, are conceptualised in this research as a behavioural benchmark characterised by procedural discipline, directive clarity, confirmation practices, and zero tolerance for ambiguity. The study employed a qualitative developmental design conducted in four phases: (1) needs analysis, (2) conceptual framework development, (3) pilot classroom implementation, and (4) expert validation. Data for needs analysis were collected from six TVET academic staff from three Malaysian institutions through focus group discussions, and two experienced Malaysian semiconductor engineers. In addition to confirming communicative behaviours identified in previous literature (directive interpretation, clarification behaviour, and procedural accountability), the TVET educators and industry practitioners highlighted the prevalent issues, including assumption-based compliance, avoidance of clarification, and limited anticipation of procedural consequences in industrial supervised environments. A behavioural communication framework was constructed from the confirmed and identified themes, drawing on literature on Speech Act Theory, Institutional Discourse, and AI-supported reflective learning. The proposed model was piloted for 4 weeks among 48 diploma-level TVET students, who engaged with AI-supported reflective learning in comprehending and practising the rules in the framework. The students' pre- and post-pilot reflective responses and researchers' observations demonstrated measurable shifts in directive interpretation and confirmation behaviour, and enhanced metacognitive awareness of SOP compliance, demonstrating the framework's feasibility in AI-supported classroom learning. Following minor refinements from a validation panel, the resulting framework attests that cleanroom culture can serve as an effective behavioural model for strengthening workforce readiness without requiring technical simulation. This study contributes to TVET communication pedagogy by integrating AI-supported reflective scaffolding into industry-aligned curriculum design.

Keywords: TVET, cleanroom culture, SOP discipline, workforce readiness, pragmatics, AI-supported learning

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1 Introduction

TVET institutions are increasingly expected to produce graduates who are not only technically competent but behaviourally prepared for highly regulated industrial environments. Cleanroom-regulated industries operate under strict Standard Operating Procedures (SOPs) where ambiguity can result in operational risk. Communication in such environments demands clarity, confirmation, and accountability. Despite these requirements, pedagogical observations indicate that students exhibit deficiencies in directive interpretation and seeking clarification, leading to reliance on assumption-based compliance.

To address these issues, this study focuses on creating a cleanroom-based behavioural communication framework implemented in TVET classrooms to prepare students for industrial integration. Departing from technical engineering analyses, this research positions cleanroom environments as behavioural benchmarks that exemplify procedural discipline, directive clarity, confirmation practices, and accountability. By translating these institutional communication norms into pedagogical constructs, this study adopts a qualitative developmental design to develop and evaluate an AI-supported behavioural framework for SOP-oriented workforce readiness in TVET contexts.

2 Literature

Workforce readiness encompasses communication clarity, discipline, adaptability, and professional accountability (Yorke, 2006). In strictly controlled environments such as cleanrooms, readiness extends to procedural reliability and accurate interpretation of directives.

These elements of readiness find theoretical grounding in Speech Act Theory, which explains that directives impose obligation (Austin, 1962; Searle, 1969). In institutional discourse, failure to recognise a speaker's intended communicative action, purpose, or function results in misalignment between instruction and action, leading to critical operational failures. Furthermore, Face-threatening Acts (FTA), which involve the need to preserve one's self-image, may influence students' willingness to seek clarification, thereby affecting communication accuracy and adherence to procedural expectations (Brown & Levinson, 1987). Consequently, there is a critical need for a framework that prepares undergraduates with the communication behaviours expected in regulated environments without threatening their professional self-image. This need motivates the present study. Moreover, the field of workforce discipline contains limited studies about AI integration, an element that is currently gaining prominence in education. AI-supported reflective learning highlights its capacity to strengthen metacognitive awareness and behavioural adjustment (Chang & Sun, 2024; Tan et al., 2025; Liu et al., 2025), which can also be extended to communicative behaviour. However, few studies integrate AI reflection with SOP-aligned workforce communication discipline, especially

in TVET contexts. This research addresses the gap between the lack of a clear guiding communication behavioural framework in compliance-driven settings and the minimal integration of AI-supported reflection in professional communication training. It proposes a behavioural communication framework tailored to industrial rule-bound environments and leverages AI to scaffold students' learning of the framework in TVET contexts. Additionally, AI-integration in learning the constructed framework offers a 'low-stakes' environment for the students, where they can practice the 'high-stakes' cleanroom communication strategies without the fear of losing face in front of other colleagues or supervisors. Recent developments in AI-supported learning emphasise its role in enhancing reflective practice and communication skills in higher education (Holmes et al., 2022; Luckin et al., 2023; Kasneci et al., 2023; Mollick, 2024).

3 Methodology

3.1 Research Design

This study employed an iterative qualitative developmental research design comprising four sequential phases: (1) needs analysis, (2) conceptual framework development, (3) pilot classroom implementation, and (4) expert validation. This design enabled the systematic construction of a communication behavioural alignment framework and an assessment of feasibility within a classroom setting without engaging in technical industrial simulation.

3.2 Phase 1: Needs Analysis

Needs analysis was conducted through focus group discussions with six TVET lecturers (three from Politeknik Seberang Perai and three from Politeknik Sultan Abdul Halim Mu'adzam Shah). Discussions focused on students' ability to interpret directives, engage in clarification behaviour, and demonstrate procedural accountability during classroom-based instruction (Yorke, 2006).

Industry perspectives were obtained from two practitioners in semiconductor-related environments. These insights highlighted the importance of confirmation behaviour, clarity of instruction, and preventive verification practices in regulated workplaces.

In addition to identifying key elements of cleanroom communication, the interviewees highlighted critical issues in rule-bound environments, including assumption-based compliance, avoidance of clarification, and limited anticipation of procedural consequences. These insights directly informed the development of the framework.

3.3 Phase 2: Framework Development

Drawing on needs analysis findings and relevant literature on Speech Act Theory (Austin, 1962; Searle, 1969), institutional discourse, and AI-supported reflective learning (Luckin et al., 2023; Zawacki-Richter et al., 2019), a conceptual framework was developed.

The behavioural communication framework (see Fig.1) comprises directive recognition, clarification engagement, confirmation prior to action, accountability projection, and AI-supported reflective reinforcement. The framework emphasises transferable procedural discipline applicable across regulated industries (see Figure 1 for a visual representation). The diagram illustrates how contextual academic and industry inputs inform the behavioural alignment cycle, which is reinforced through AI-supported metacognitive reflection to produce SOP-aligned workforce readiness. While multiple AI tools were accessible to students, a standardised prompt framework was applied to maintain consistency in AI-generated feedback.

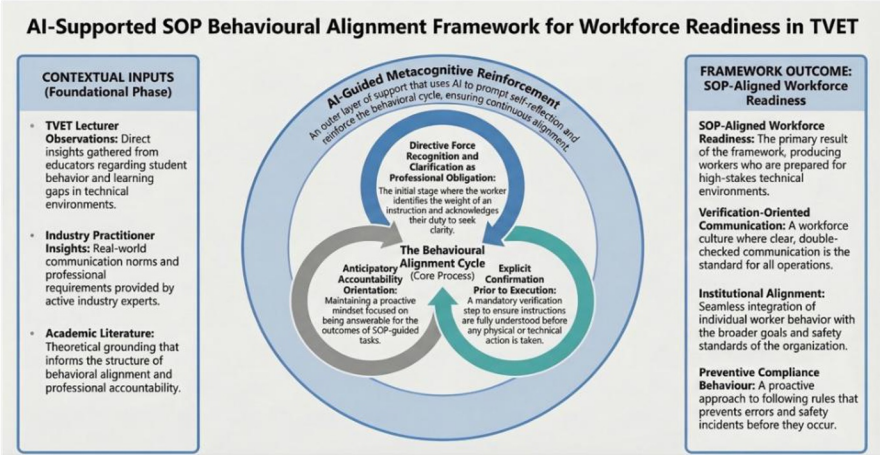

Fig. 1. AI-supported SOP Behavioural Alignment Framework for Workforce Readiness in TVET Contexts.

3.4 Phase 3: Pilot Classroom Implementation

A small-scale pilot implementation was conducted with 48 diploma-level TVET students enrolled in a campus-based communication module prior to industrial internship placement. The participants were from the Department of Mechanical Engineering (JKM) and the Department of Electrical Engineering (JKE) at a Malaysian polytechnic and were enrolled in Communicative English 3 (DUE50032), a Semester 5 course designed to develop workplace communication competencies, including professional interaction, job enquiries, and interview performance.

The selected cohort comprised Semester 5 students preparing for compulsory industrial training in Semester 6. This group was intentionally chosen as they were transitioning from classroom learning to supervised industry placement. As they would soon be required to communicate in regulated industrial environments such as manufacturing facilities and cleanrooms, they represented an appropriate population for examining behavioural readiness in structured workplace communication.

The pilot was conducted over three structured sessions within a four-week instructional period. To provide a clearer illustration of how the framework was operationalised in a classroom setting, a step-by-step implementation model is presented in Figure 2.

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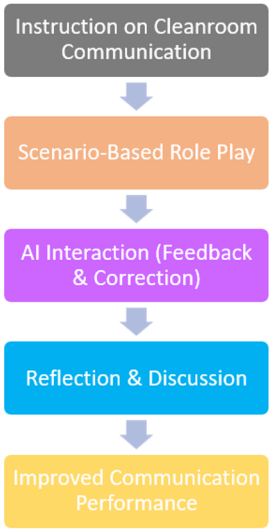

Fig. 2. Step-by-Step Classroom Implementation of the AI-Supported Cleanroom Communication Framework

Figure 2 illustrates the step-by-step implementation of the framework, progressing from instruction to practice and reflective reinforcement. During these sessions, students engaged in directive paraphrasing exercises, confirmation question formulation tasks, reflective consequence anticipation activities, and AI-guided prompts requiring rephrasing and verification responses.

AI tools functioned as reflective scaffolding to enhance students' metacognitive awareness. Although multiple AI tools were accessible, a standardised prompt framework was applied to maintain consistency in AI-generated feedback. The objective of this pilot phase was not to establish statistical effectiveness but to examine behavioural feasibility and reflective engagement within instructional constraints. The framework

was implemented within the Communicative English 3 (DUE50032) module, with one of the researchers serving as the course instructor.

Learning Activities. To introduce the framework, students participated in a series of structured communication activities designed to simulate regulated workplace interaction. These activities included:

Scenario-Based Role-Play. Students were given short workplace scenarios involving task instructions, procedural clarification, and responsibility confirmation. They were required to practise asking clarifying questions before executing instructions.

Cleanroom Communication Simulations. Students analysed simulated workplace situations where misinterpretation of instructions could lead to operational errors. They practised responding using clarification and confirmation strategies aligned with the framework.

Guided Reflection Exercises. Students reflected on their communication decisions and discussed how clarification, confirmation, and accountability behaviours influence workplace outcomes.

AI-Assisted Reflection Prompts. Students interacted with AI-generated prompts that encouraged metacognitive reflection on how professional communication behaviours should be applied in controlled environments such as industrial production settings.

AI Implementation and Standardisation. AI tools such as ChatGPT and Google Docs Voice Typing were used as reflective scaffolding to enhance students' metacognitive awareness. Students interacted with AI by inputting responses from scenario-based activities, including role-play transcripts and written reflections.

To ensure consistency and reduce variability in AI-generated responses, all students were required to use a standardised prompt framework. A standardised prompt used in the study is as follows:

"The following response may contain communication errors. Analyse and improve it based on clarity, politeness, and adherence to standard operating procedures."

This standardisation enabled all participants to receive comparable feedback, thereby enhancing the reliability of the reflective learning process while maintaining both pedagogical flexibility and methodological consistency.

3.5 Pilot Evaluation Approach

The pilot implementation aimed to evaluate the feasibility and behavioural relevance of the framework rather than to produce large-scale quantitative evidence. Two forms of data were used during the pilot phase.

Scenario-Based Performance Observation. Students were first presented with a workplace scenario requiring interpretation of task instructions. In small groups, they enacted the scenario and demonstrated how they would respond to the directive. These interactions were observed to identify how students interpreted instructions and whether clarification behaviours were used before the pilot test.

Following the instructional sessions introducing the framework (the pilot test), students were given a second scenario-based task requiring them to respond to workplace directives using clarification and confirmation strategies. The responses were compared qualitatively to identify shifts in communication behaviour.

Reflective Student Responses. Students also completed short written reflections describing how their perception of clarification and responsibility in workplace communication changed after exposure to the framework. These reflections provided qualitative insight into students' behavioural reasoning.

Scenario-Based Performance Observation. To examine behavioural changes following the introduction of the framework, students participated in a scenario-based activity before and after the instructional intervention. In the pre-instruction phase, students were presented with a workplace communication scenario involving task instructions within a regulated production environment. Students performed short role-play interactions in small groups to demonstrate how they would respond to the directive.

After the framework was introduced and practised through guided classroom activities, students were given a second scenario requiring clarification and confirmation of instructions prior to task execution. The purpose was to observe whether students demonstrated increased awareness of directive interpretation, clarification behaviour, and responsibility confirmation.

Observations were recorded using a simple behavioural observation rubric focusing on communication patterns relevant to the framework constructs, as presented in Table 1.

Table 1. Table captions should be placed above the tables.

Behaviour Indicator	Pre-Instruction Observation	Post-Instruction Observation
Recognition of directive intent	Students interpreted instructions passively without verifying meaning	Students demonstrated greater awareness of directive intent and asked clarification questions
Clarification behaviour	Students avoided asking follow-up questions due to hesitation	Students more frequently requested clarification
Confirmation before execution	Instructions were accepted without confirmation	Students confirmed instructions before proceeding

Accountability	Students assumed errors could be corrected later	Students emphasised confirming instructions to prevent mistakes

3.6 Phase 4: Expert Validation

The conceptual framework was reviewed by one academic expert from Universiti Tunku Abdul Rahman and two industry practitioners. Validation focused on clarity, relevance, transferability, and pedagogical practicality. The feedback affirmed the framework's behavioural focus and alignment with industry expectations, with minor suggestions for terminology refinement.

3.7 Data Analysis

Thematic analysis was conducted following Braun and Clarke's (2006) six-phase approach. Data sources included lecturer discussions, student reflective responses, researchers' observation notes, and expert feedback. Credibility was strengthened through triangulation and peer debriefing. Student reflective responses were collected at the beginning and end of the pilot sessions to illustrate shifts in directive interpretation and confirmation behaviour; pre- and post-pilot observations by the researchers

4 The AI-Supported SOP Behavioural Alignment Framework

The AI-Supported SOP Behavioural Alignment Framework conceptualises cleanroom culture as a behavioural discourse model rather than a technical engineering system. Rather than replicating industrial environments, the framework translates institutional communication norms characteristic of regulated contexts into pedagogically transferable constructs for TVET instruction.

At the core of the framework lies Behavioural Alignment, defined as the disciplined integration of directive recognition, clarification responsibility, confirmation practice, and anticipatory accountability within professional communication. Behavioural alignment represents the internalisation of procedural discipline as communicative competence rather than mere mechanical compliance. The framework comprises three interdependent behavioural constructs arranged within a behavioural alignment cycle and reinforced by an outer AI-guided metacognitive layer.

4.1 Directive Force Recognition and Clarification as Professional Obligation

Observations from the scenario-based activities, recorded using the behavioural observation indicators presented in Table 1, indicated noticeable changes in students' approach to directive interpretation, clarification, and responsibility confirmation.

The first construct emphasises recognition of illocutionary force in institutional directives (Searle, 1969). In regulated environments, instructions carry procedural authority and implicit obligation. Failure to recognise directive force often results in assumption-based continuation rather than verified compliance.

This construct reframes clarification from a socially risky act into a professional responsibility. Drawing on politeness theory (Brown & Levinson, 1987), the framework acknowledges that learners may avoid clarification to preserve perceived competence. Through structured rehearsal, clarification is repositioned as preventive accountability rather than face-threatening behaviour.

4.2 Explicit Confirmation Prior to Execution

The second construct institutionalises confirmation practices before task initiation. Rather than relying on internal interpretation, learners engage in externalised verification through paraphrasing, confirmation drafting, and acknowledgement of intended action.

Explicit confirmation prior to execution reduces interpretive drift and aligns communicative behaviour with procedural reliability. Within regulated industries, confirmation functions as a preventive mechanism against assumption-based error. This construct cultivates disciplined communication habits transferable across professional domains.

4.3 Anticipatory Accountability Orientation

The third construct shifts accountability from reactive correction to proactive anticipation. Learners are guided to project potential consequences before action occurs, thereby aligning behaviour with institutional expectations of preventive discipline.

Anticipatory accountability orientation fosters a verification mindset in which responsibility is activated prior to procedural execution. Rather than correcting errors retrospectively, learners internalise accountability as forward-looking risk mitigation.

4.4 AI-Guided Metacognitive Reinforcement

Surrounding these behavioural constructs is a continuous AI-guided metacognitive reinforcement layer. AI functions as reflective scaffolding that prompts learners to rephrase directives, formulate confirmation statements, and anticipate procedural consequences. Through structured cognitive rehearsal, AI strengthens deliberate engagement with directive force, clarification norms, and accountability reasoning. Importantly, this reinforcement mechanism supports behavioural discipline without requiring technical simulation of industrial settings.

The framework is conceptual, scalable, and transferable across regulated industrial communication environments. It provides a structured pedagogical model for embedding procedural communication discipline within TVET curricula aligned with industry expectations. As illustrated in Figure 1, the framework conceptualises cleanroom culture as a behavioural discourse model.

4.5 Framework Mechanism and Theoretical Positioning

The AI-Supported SOP Behavioural Alignment Framework can be conceptualised as a behavioural alignment mechanism that integrates institutional discourse principles with reflective learning processes. The framework operates through a cyclical interaction between directive interpretation, clarification activation, and confirmation practices, which collectively guide learners toward anticipatory accountability in communication behaviour.

At the behavioural level, the framework translates institutional communication norms characteristic of regulated environments into pedagogically transferable constructs. Directive recognition activates the learner's awareness of illocutionary force, while clarification and confirmation behaviours function as verification mechanisms that minimise interpretive ambiguity.

At the cognitive level, AI-guided reflective prompts serve as metacognitive scaffolding that encourages learners to analyse communication decisions, anticipate procedural consequences, and internalise verification-oriented communication habits.

This interaction between behavioural rehearsal and reflective reinforcement positions the framework as a hybrid pedagogical model integrating pragmatics, institutional communication discipline, and AI-supported metacognitive learning. Rather than replicating technical industrial environments, the framework operationalises the behavioural logic of regulated communication systems within accessible classroom settings.

Consequently, the framework contributes to TVET communication pedagogy by demonstrating how institutional communication discipline can be systematically translated into educational practice through reflective behavioural alignment.

5 Findings and Framework Implications

To evaluate the effectiveness of the framework, pre- and post-scenario role-play activities were conducted. Students were given simulated cleanroom communication tasks before and after exposure to the framework. Their performances were observed using structured behavioural indicators focusing on directive recognition, clarification behaviour, confirmation practices, and accountability orientation. This approach enabled qualitative comparison of students' communicative development within a controlled classroom setting.

5.1 Overview of Observed Behavioural Shifts

The pilot classroom implementation provided preliminary insight into how students interpreted workplace directives and how their communication behaviour evolved after exposure to the proposed framework. Observations from the scenario-based activities indicated noticeable changes in students' approach to directive interpretation, clarification, and responsibility confirmation.

During the pre-instruction scenario, many students demonstrated a tendency to accept instructions without questioning or verifying the intended meaning. Several interactions revealed hesitation to request clarification, suggesting that students may perceive clarification as socially uncomfortable or unnecessary. This behaviour reflects patterns described in pragmatic communication literature where individuals avoid clarification due to perceived face-threatening implications.

Following the instructional introduction of the framework and related communication exercises, students demonstrated greater willingness to request clarification and confirm instructions prior to task execution. These behavioural shifts suggest that framing clarification as a professional responsibility rather than a sign of misunderstanding can influence students' communication approach in structured workplace contexts.

5.2 Directive Interpretation and Clarification Behaviour

One of the most noticeable changes observed during the pilot activities involved students' interpretation of workplace directives. Prior to the instructional intervention, several students interpreted instructions as fixed commands that should be followed without further discussion.

Reflective responses revealed this perception clearly. One student explained:
"I don't want to ask again because it may look like I don't understand."

This response reflects a common concern associated with face-threatening communication situations, where individuals avoid clarification to protect social image.

After exposure to the framework, however, students began to reinterpret clarification as part of professional responsibility. One student reflected:
"Repeating instructions shows responsibility."

This shift suggests that students began to recognise clarification not as a sign of incompetence but as an important step in preventing operational errors.

5.3 Confirmation Prior to Task Execution

Another behavioural shift was observed in how students approached confirmation of instructions before performing a task. During the pre-instruction scenario activities, students typically proceeded with task interpretation without explicitly confirming the directive.

This behaviour indicates a reactive communication approach, where individuals assume that any misunderstandings can be corrected later.

After participating in the instructional activities aligned with the framework, students increasingly demonstrated explicit confirmation behaviour. Students began to repeat instructions or summarise the directive to ensure accurate understanding before acting.

These behaviours reflect the framework component referred to as explicit confirmation prior to execution, which emphasises verification as a preventative communication practice in regulated environments.

5.4 Accountability Orientation

The framework also emphasises anticipatory accountability orientation, referring to the awareness that communication decisions can influence operational outcomes.

Prior to the instructional intervention, several students expressed a reactive mindset regarding workplace communication. For example, one student noted:
"If something is wrong, I can fix it later."

Such responses suggest that responsibility was perceived primarily as correcting errors rather than preventing them.

Following exposure to the framework and guided reflection activities, students demonstrated a shift toward preventive thinking. One reflection indicated:
"It is better to confirm first because mistakes can affect others."

This shift illustrates movement from reactive correction to preventive responsibility awareness, which aligns with professional expectations in regulated operational environments.

5.5 Role of AI-Supported Reflection

An additional element of the framework involved AI-supported reflective prompts designed to encourage metacognitive awareness of communication decisions. Students were guided to analyse workplace scenarios and reflect on how clarification, confirmation, and responsibility behaviours influence operational outcomes.

The reflective exercises appeared to support students in reconsidering their communication habits and recognising the professional importance of explicit instruction verification. These reflections reinforced the behavioural components embedded in the framework and helped students connect communication decisions with workplace accountability.

5.6 Implications for Communication Training in Regulated Environments

While the present pilot involved a single instructional context, the findings provide preliminary evidence that structured communication frameworks can support behavioural readiness for communication in regulated industrial environments.

The framework provides a pedagogical structure that instructors can use to guide communication training through scenario-based activities, role-play simulations, and reflective discussion. By emphasising clarification as a professional responsibility rather than a social risk, the framework addresses a common barrier to effective communication in regulated operational settings.

Although the pilot implementation involved a single classroom context, the observed behavioural shifts indicate that structured communication frameworks may help students develop greater awareness of directive interpretation and responsibility-based communication before entering industrial training environments.

6 Extended Analysis of Behavioural Patterns

To illustrate behavioural shifts observed during the pilot implementation, a qualitative comparison of pre- and post-instruction communication patterns was conducted through scenario-based classroom activities and reflective student responses (see Table 2). The pilot phase focused on examining whether students demonstrated increased awareness of directive interpretation, clarification behaviour, and accountability reasoning after exposure to the framework.

Table 2. Pre-Intervention Pattern and Post-Intervention Shift

Theme	Pre-Intervention Pattern	Post-Intervention Shift
Directive Interpretation	Assumption-based continuation	Verification before action
Clarification Behaviour	Avoidance due to face concerns	Clarification framed as responsibility
Accountability Orientation	Reactive correction	Preventive verification mindset

Directive Interpretation. Prior to the instructional intervention, students frequently interpreted directives as fixed instructions that should be followed without additional verification. This behaviour reflected an assumption-based continuation pattern in which students relied on personal interpretation rather than confirmation of intended meaning. Following exposure to the framework, students increasingly demonstrated verification behaviour, including asking clarifying questions and confirming instructions before proceeding with a task.

Clarification Behaviour. Pre-intervention interactions revealed hesitation among students to request clarification. Several students indicated that asking questions might signal lack of competence. This aligns with pragmatic research suggesting that clarification requests may be perceived as face-threatening acts in hierarchical or instructional contexts. After participating in framework-based activities, students began to reinterpret clarification as a professional responsibility rather than a social risk.

Accountability Orientation. Another notable shift involved students' perception of responsibility. In the pre-instruction scenario, several responses reflected a reactive mindset, in which errors were assumed to be correctable after task completion. Following instructional exposure, students increasingly emphasised preventive verification, suggesting a developing awareness of anticipatory accountability aligned with regulated workplace expectations.

7 Discussion

The thematic patterns identified in the pilot illustration indicate a measurable shift in students' conceptualisation of directive compliance, clarification responsibility, and procedural accountability. While the pilot phase was exploratory in nature, reflective responses indicate meaningful shifts in how students conceptualised procedural communication within regulated contexts.

The framework also suggests pedagogical strategies that instructors can employ to reinforce communication behaviour in controlled workplace environments. These include scenario-based simulations, structured clarification exercises, responsibility confirmation tasks, and reflective discussion activities. Such activities enable students to practise recognising directive intent, confirming instructions prior to execution, and anticipating accountability within regulated operational contexts.

The framework reflects the theoretical foundations that informed its development. Elements of Speech Act Theory guide the interpretation of directives and the need for clarification when communicative intent is ambiguous. Concepts related to Face-Threatening Acts (FTA) help explain why individuals may avoid clarification due to perceived social risk. The framework addresses this behaviour by reframing clarification as a professional obligation rather than a face-threatening act.

In addition, principles of industrial communication and organisational responsibility inform the emphasis on confirmation and accountability prior to task execution. By integrating these theoretical perspectives, the framework links pragmatic communication theory with practical behavioural expectations in regulated workplace environments.

7.1 Directive Interpretation: From Assumption to Verification

Pre-intervention reflections revealed a tendency toward assumption-based compliance. One representative response stated: "If I think I understand, I just continue." The phrase "I think" signals subjective interpretation rather than procedural verification. From a speech act perspective, this reflects incomplete recognition of illocutionary force, where the directive is interpreted as optional understanding rather than obligatory action (Searle, 1969).

Following pilot implementation, reflective responses demonstrated a shift toward explicit verification behaviour. A post-intervention comment stated: "I confirm first before acting because wrong assumption can affect others." The lexical transition from "think" to "confirm" indicates movement from internal interpretation to externalised procedural accountability. This shift aligns with institutional discourse norms in regulated environments, where directive compliance requires verification rather than inference (Urbanik, 2024).

This transition suggests that structured reflective scaffolding may support students in recognising directive force as professional obligation rather than personal interpretation.

7.2 Clarification Behaviour: From Face-Saving to Professional Responsibility

Clarification practices exhibited a similar recalibration. Pre-intervention reflections frequently indicated avoidance rooted in social perception. One student expressed: "I don't want to ask again because it may look like I don't understand." This illustrates the influence of face-saving orientation described by Brown and Levinson (1987), where individuals avoid clarification to protect perceived competence.

Post-implementation reflections demonstrated a reframing of clarification as responsibility rather than weakness. A representative response noted: "Repeating instructions shows responsibility." This shift indicates a movement from interpersonal anxiety toward institutional alignment, where clarification functions as preventive verification rather than evidence of incompetence.

Such reframing is particularly significant in regulated professional environments, where ambiguity may produce procedural risk. The pilot suggests that AI-guided reflective rehearsal can assist learners in redefining clarification as a professional norm rather than a social vulnerability.

7.3 Accountability Orientation: From Reactive Correction to Preventive Verification

A third notable shift emerged in accountability orientation. Pre-intervention responses suggested reactive reasoning, as reflected in statements such as: "If something is wrong, I can fix it later." This perspective reflects a correction-based mindset, where accountability is activated only after error occurs.

Following the pilot implementation, reflective responses demonstrated anticipatory thinking. One student observed: "It is better to confirm first because mistakes can affect others." This indicates movement toward preventive verification, aligning more closely with institutional expectations of procedural discipline. Rather than responding to error retrospectively, students began to articulate responsibility as proactive risk mitigation.

This recalibration supports the framework's emphasis on accountability projection, where learners anticipate consequences before action rather than after correction.

7.4 Role of AI-Supported Reflective Scaffolding

The behavioural shifts observed across themes appear linked to structured AI-guided reflective prompts. Students were required to paraphrase instructions, generate confirmation questions, and anticipate procedural consequences. This repeated metacognitive rehearsal encouraged deliberate engagement with directive force, clarification norms, and accountability reasoning.

Importantly, AI functioned as reflective scaffolding rather than evaluative automation. The prompts facilitated structured cognitive rehearsal of institutional communication norms without simulating technical industrial conditions. This supports previous findings that AI tools can enhance metacognitive awareness and behavioural adjustment when used as guided reflection aids (Luckin et al., 2023; Zawacki-Richter et al., 2019).

7.5 Theoretical and Pedagogical Contributions

Theoretically, this study contributes by reframing cleanroom culture as a behavioural discourse model rather than a technical engineering construct. By grounding the framework in speech act theory and institutional communication principles, the study positions procedural discipline as a communicative competence transferable across regulated industries.

Pedagogically, the findings suggest that AI-supported reflective scaffolding can operationalise procedural verification, clarification responsibility, and accountability anticipation within mainstream TVET instruction. Rather than requiring specialised industrial facilities, behavioural rehearsal can be embedded within classroom communication modules.

The proposed framework therefore offers a scalable and transferable model for cultivating SOP-aligned workforce readiness while remaining accessible to educational institutions without technical simulation environments.

Unlike traditional workplace communication training models that emphasise general interpersonal competence, the proposed framework specifically operationalises directive interpretation, verification behaviour, and anticipatory accountability as structured communicative competencies aligned with regulated industrial environments.

8 Limitations and Future Research

This study presents a developmental framework with a small-scale pilot illustration. The pilot phase was conducted within a classroom setting rather than an industrial environment. Therefore, findings indicate behavioural feasibility rather than direct workplace performance validation. Future research may include longitudinal industry-based implementation studies.

9 Conclusion

Cleanroom behavioural discipline can be pedagogically translated into TVET communication training through structured AI-guided reflective scaffolding. By aligning pragmatics, institutional discourse norms, and metacognitive rehearsal with industry expectations, educators can cultivate disciplined, verification-oriented graduates prepared for regulated professional environments. The framework offers a scalable foundation for integrating behavioural accountability into industry-aligned training ecosystems, demonstrating that communication discipline can be systematically developed through AI-supported reflective rehearsal.

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