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Fostering collaborative learning in ESP: AI-driven approaches integrating learning styles and multiple intelligences

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ABSTRACT

The growing demand for English for Specific Purposes (ESP) calls for innovative learning methodologies that address diverse cognitive profiles. However, traditional ESP education often overlooks individual learning styles and multiple intelligences. This study explores how AI can enhance collaborative ESP learning by accommodating varied learning preferences, asking: How can AI improve collaborative ESP training by adapting to diverse learning styles and intelligences? A mixed-methods experimental design involved 100 university students from Engineering, Medicine, and Business, divided into experimental and control groups. The experimental group received AI-supported collaborative ESP training tailored to their learning styles and intelligences, while the control group followed conventional methods. Results showed the experimental group demonstrated significantly higher motivation, engagement, learning outcomes, and improved communication and collaboration skills. These findings suggest that integrating AI with cognitive-based learning models enhances collaborative ESP environments through adaptive content delivery, dynamic grouping, and personalized feedback, fostering more inclusive and effective professional language learning.

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1. Introduction

The globalization of corporations, education, and research has increased demand for English for Specific Purposes (ESP) in the 21st century (AlTwijri & Alghizzi, 2024; Song & Song, 2023; Vaishnav, 2024). Unlike General English, ESP meets students' language and communication needs in business, engineering, medicine, and law. Educators must address students' cognitive and professional needs in this specialization (Oxford et al., 2024; Zeng, 2021). Traditional ESP training may not account for learners' cognitive abilities, goals, and learning styles. Educational psychology research shows children learn best when teachers match their learning styles and intelligences. Recently, AI has transformed education by offering personalized tutoring, feedback, and customizable learning systems (Akgun & Greenhow, 2022; Huang et al., 2022; Mahmoud & Sørensen, 2024). In ESP contexts where specialized knowledge acquisition is crucial, AI-driven solutions provide customized training for multiple intelligences and learning styles.

Collaborative learning is gaining popularity as an educational tool, promoting critical thinking, knowledge-sharing, and problem-solving (Eskiyurt & Özkan, 2024; Lestari & Wahyudin, 2020; W. Yang, 2022; X. Yang, 2023). Collaborative learning helps ESP students become communicative by encouraging authentic, discipline-specific discourse (Alnufaie & Alzahrani, 2024; Bai & Wang, 2023a; Sun et al., 2021; Sung et al., 2008). Using AI in team ESP education allows for creative customization and participation.

Research shows that AI-driven education increases vocabulary retention, reading comprehension, and writing (Bai & Wang, 2023b; Dwinalida & Setiaji, 2020; Guo et al., 2021; Song & Song, 2023). Chatbots, adaptive learning platforms, and NLP-based assessment tools give students quick feedback and personalised learning routes (AlTwijri & Alghizzi, 2024; Lestari & Wahyudin, 2020; Oxford et al., 2024). According to research on Multiple Intelligences Theory (MIT) (Gardner, 1983) and Learning Styles Theory (Kolb, 1984; Felder & Silverman, 1988), cognitive preferences affect how people process and retain knowledge cited in (Peña-Acuña & Corga Fernandes Durão, 2024; Pološki Vokić & Aleksić, 2020; Taylor et al., 2021). Since ESP students have various educational backgrounds, cognitive abilities, and professional goals, personalized training is necessary for success (Pastor et al., 2021; Sun et al., 2021). Artificial intelligence can help adaptive learning, but its interplay with ESP and learning styles is unknown. Collaborative learning improves student engagement and academic success in ESP situations where communication and problem-solving skills are essential.

Recent advances in AI have enabled intelligent collaborative learning environments (Alnufaie & Alzahrani, 2024; Oxford et al., 2024). These systems create dynamic groups based on student strengths and weaknesses using real-time data analytics, speech recognition, and machine learning algorithms (Baiq et al., 2022; Shahsavar et al., 2024). ESP's AI-driven collaborative learning's adaptability to varied intelligences and learning styles has not been well studied. Few studies have examined their intersection, although others have examined the benefits of AI-driven learning, learning styles, multiple intelligences, and collaborative learning in ESP. The literature lacks integrative frameworks for ESP education that include AI, cooperative learning, and cognitive diversity. Few opportunities for peer-assisted learning and socialization (Laadem & Mallahi, 2020; Song & Song, 2023). Current AI-based ESP models prioritize individualized learning paths over cooperative engagements, limiting possibilities.

Most AI-driven ESP applications ignore learners' learning styles and intelligence, which may cause a mismatch between instructional delivery and student needs (Khoiriyah, 2021; Maghsudi et al., 2021; Vistorte et al., 2024). Lack of studies on how artificial intelligence may dynamically adapt collaborative learning activities based on learners' cognitive profiles hinders ESP environments' ability to enhance engagement, motivation, and information retention. This discrepancy necessitates an empirical investigation on how artificial intelligence might strategically foster cooperation while considering learner characteristics. ESP needs a paradigm that maximizes collaborative learning situations and leverages artificial intelligence for adaptive learning based on multiple intelligences and learning styles. We provide an AI-driven collaborative learning framework for ESP that uses many intelligences and learning styles to boost student engagement, motivation, and language acquisition. We investigate how AI-powered adaptive learning systems might enable dynamic group construction, content delivery customisation, and peer interaction optimization based on learner cognitive profiles.

To assess the success of our strategy in promoting cooperative learning, we use a mixed-methods approach combining qualitative observations from student interactions with quantitative analysis of learning results. We want to close the distance between individualized instruction and group involvement in ESP by using artificial intelligence's capacity to interpret real-time learner data. This work has the following main goals:

1. To explore how AI can facilitate collaborative learning in ESP while considering multiple intelligences and learning styles.
2. To evaluate the impact of AI-driven personalized instruction on student motivation and engagement in ESP.

To develop and test a model that dynamically adjusts collaborative tasks based on learners' cognitive preferences.

2. Literature review

2.1. Artificial intelligence in language education

AI in language teaching has transformed learner engagement with material, educators, and peers. AI technologies, such as tutoring systems, adaptive learning platforms, chatbots, and NLP-based feedback tools, have greatly enhanced English language acquisition personalization (Huang et al., 2022; Mahmoud & Sørensen, 2024). These technologies serve individual needs more effectively than conventional education with real-time evaluation, automatic error correction, and adaptive learning suggestions based on student feedback.

In English for Specific Purposes (ESP), artificial intelligence improves vocabulary retention, reading comprehension, pronunciation, and specialist writing (Bai & Wang, 2023b; Song & Song, 2023). AI-driven grammar checkers, speaking practice bots, and contextual translation systems help students acquire technical terms and discourse structures. These tools help educators track progress, identify learning gaps, and intervene quickly, making ESP instruction more efficient and data-driven.

Despite these advances, AI in language instruction focuses on individualized learning trajectories. Most AI systems enable self-directed learning and tailored coaching, with few collaborative features (Rukiati et al., 2023; Wei, 2023). This undervalues peer feedback, collaboration, and discourse negotiation, which are crucial to language development. This personal attention hinders ESP situations that require communication and professional teamwork. A gap exists in using AI to improve group-based learning environments that promote interaction, cognitive diversity, and real-time learner cooperation. Optimizing AI in English for education requires reducing this limitation.

2.2. Learning styles and multiple intelligences in ESP pedagogy

The use of learning styles and intelligences has greatly affected learner-centered education. Gardner's 1983 Theory of Multiple Intelligences states that people's linguistic, logical-mathematical, interpersonal, and intrapersonal intelligences affect their information processing. Kolb's Experiential Learning Theory (1984) states that visual, auditory, and kinesthetic learners perform best when instruction matches their sensory and cognitive preferences. Felder and Silverman (1988) defined active-reflective, sensing-intuitive, and visual-verbal learning styles, emphasizing the need for individualized instruction.

Cognitive profiles improve learning results, according to empirical studies. According to (Gacusan et al., 2023; Taylor et al., 2021), students who engaged with content that matched their cognitive preferences retained, motivated, and understood more. Yusof et al. (2023) found that matching instructional materials to students' learning styles improves engagement and collaboration. These language training methods improve students' understanding, generating, and thinking about language in important contexts.

English for Specific Purposes (ESP) learners have various professional, disciplinary, and cultural backgrounds, highlighting cognitive diversity. Language and domain-specific knowledge conceptions must be considered in ESP instruction. Business students may appreciate interpersonal simulations, whereas engineers may like logical-sequential assignments. Universal strategies often fail to meet these complex needs. Thus, ESP teaching incorporates learning styles and many intelligences to make education adaptive, inclusive, and professionally relevant, boosting linguistic competency and contextual communication skills for practical application.

2.3. Collaborative learning in ESP contexts

Socio-constructivist theory underpins collaborative learning, which holds that social interaction and collective meaning-making build knowledge (VYGOTSKY, 1980; X. Yang, 2023). Collaboration is important in English for Specific Purposes (ESP) because it meets professional communication needs like teamwork, negotiation, and problem-solving. Collaborative learning enhances language application, critical analysis, and communication abilities through peer discussions, group projects, and simulations (Eskiyurt & Özkan, 2024; Veramuthu & Md Shah, 2020). Cooperative settings that mimic professional activity benefit ESP learners. Engineering students learning technical documentation and business students practicing mock negotiations learn domain-specific discourse and contextualized language. Collaborative learning improves interpersonal skills, learner confidence, and idea sharing across cognitive and linguistic backgrounds (Chavarría & Avalos, 2022). Collaboration is crucial to English for Specific Purposes training because it improves language and professional preparation.

However, traditional group-based learning methods have many challenges. Unequal involvement or domination by some individuals often results from the group makeup not matching learners' cognitive or interpersonal skills (Laadem & Mallahi, 2020). Static group tasks do not address learners’ shifting needs and engagement. Managing group dynamics and intervening quickly can be difficult for educators, reducing collaboration and student motivation. Collaborative learning in ESP may fail without flexible procedures.

Overcoming these limits requires adaptive and interactive collaborative frameworks that account for learners’ diverse profiles and evolving interactions. AI can improve collaboration, notably in English for Specific Purposes (ESP), where professional language proficiency is crucial.

2.4. Integrating AI with collaborative learning

AI in collaborative learning is improving student interaction, engagement, and peer-driven outcomes. Recent research shows that AI-assisted systems can improve group formation based on learner profiles, provide adaptive feedback, and assign tasks dynamically in real time. These innovations allow instructors to go beyond static group tasks and typical educational methods to encourage individualized cooperation that capitalizes on individual skills.

AI systems for collaborative learning use learning analytics and machine learning algorithms to assess student interest, involvement, and performance. Using this data, algorithms can design fair groups, give diverse jobs, and intervene quickly. Baiq et al. (2022) found that AI-enhanced collaborative platforms improved group cohesion and fair participation by adapting team configurations to learners' strengths and weaknesses.

AlTwijri and Alghizzi (2024) found significant increases in student motivation and group productivity in AI-supported classrooms with adaptive task engines for peer interaction.

Despite these promising advances, AI applications in collaborative learning often ignore group cognitive factors like learning styles and intelligences. Most AI systems use performance measurements or behavioral data instead of a cognitive profile for classification. While mainstream education has adopted these developments, English for Specific Purposes (ESP) has done so less. Cognitively attuned collaboration is beneficial for ESP instruction, which needs verbal and discipline-specific communication. AI-driven approaches for this complexity are restricted. Creating intelligent systems that adapt to learners' cognitive traits and provide socially and professionally appropriate ESP learning environments is necessary to close this gap.

2.5. Identified research gap

Despite the growing use of artificial intelligence in language acquisition, existing AI-driven English for Specific Purposes (ESP) systems rarely address psychological factors affecting group-based collaboration. Most AI systems for English for Specific Purposes (ESP) emphasize personalized training, adaptive material delivery, targeted feedback, and learning tempo manipulation. These features promote learner autonomy and engagement, but they often overlook the social aspects of language acquisition, such as collaborative interaction, discourse negotiation, and peer-assisted problem-solving, which are crucial in ESP contexts (Kim et al., 2022; Lin et al., 2023). Modern AI-enhanced learning models often ignore learning styles and the effects of various intelligences on collaboration. These systems usually group learners by academic performance or engagement rates rather than cognitive factors like their preference for visual, auditory, or kinesthetic processing or dominance in linguistic, logical, or interpersonal intelligences. Group dynamics in AI-mediated learning environments may hinder inclusion, mutual reinforcement, and communication.

Combining AI-driven customisation, cognitive diversity, and collaborative learning requires a hybrid instructional architecture immediately. A model must analyze learners' cognitive profiles, dynamically generate groups, assign activities, and provide feedback based on preferences and learning objectives. This hybrid approach can balance individualized learning and social contact in English for Specific Purposes (ESP), where professional communication and contextualized language application are essential. Creating and empirically validating such a paradigm can make AI-enhanced ESP education more inclusive, engaging, and effective for individual differences and collaborative needs.

3. Method

3.1. Research design

This mixed-methodology research project combines qualitative and quantitative methods to evaluate how well AI-driven cooperative learning works in ESP. Using an experimental pre-test and post-test design, participants are split into experimental and control groups (Nazari et al., 2021; Song & Song, 2023; Wei, 2023). Whereas the control group follows conventional ESP teaching, the experimental group participates in AI-based collaborative learning. While qualitative insights from observations and polls probe learners' experiences, quantitative data from test results evaluate learning enhancements. This method guarantees a thorough assessment of how artificial intelligence adjusts to several intelligences and learning styles, thereby improving cooperation and inspiration in ESP education.

3.2. Participants

Purposive sampling picked ESP students from Engineering, Medicine, and Business programs for a diverse sample. The study's focus on learning styles and different intelligences aligned with these disciplines' high English proficiency requirements and diverse cognitive, linguistic, and professional traits.

Institutional suggestions and past partnership agreements with ESP faculty in these areas determined the selected classes. The experimental arrangement required class collaboration and technology interventions, such as AI tools and digital infrastructure.

Students completed consent forms and validated learning style inventories and IQ questionnaires before the study. The AI-driven system needed this profile to assign participants to the experimental or control group and dynamically change content and group configurations based on cognitive attributes. The experimental group (n = 50) and control group (n = 50) had similar learning styles and IQ types, decreasing selection bias and enabling a meaningful comparison.

Table 1

Distribution of participants.

Group	Number of Participants	Learning Styles - Visual (%)	Learning Styles - Auditory (%)	Learning Styles - Kinesthetic (%)	Multiple Intelligences - Linguistic (%)	Multiple Intelligences - Logical-Mathematical (%)	Multiple Intelligences - Interpersonal (%)
Experimental	50	40	30	30	35	30	35
Control	50	35	35	30	40	25	35

This study concentrated on the three most pertinent cognitive domains from Gardner’s Multiple Intelligences hypothesis in the context of English for Specific Purposes (ESP): linguistic, logical-mathematical, and interpersonal intelligences. These three were chosen because they are directly associated with collaborative learning tasks, communication, problem-solving, and analytical activities commonly integrated into ESP courses.

Alternative intelligences, including musical, naturalistic, and bodily-kinesthetic, while beneficial in normal educational settings, were deprioritized in this research due to their restricted relevance to the language-centric and technology-driven activities employed in the intervention. Initially, the participant profile encompassed a comprehensive MI assessment; however, to enhance clarity and statistical precision, this study employed only the predominant three intelligences for data categorization and analysis.

Figure 1

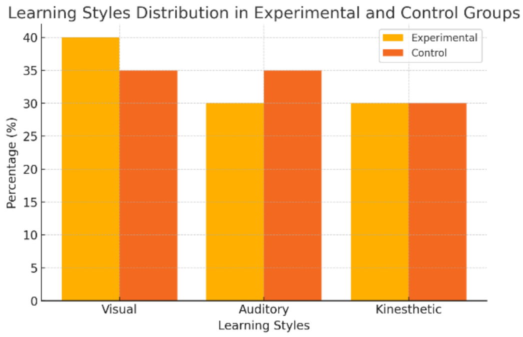
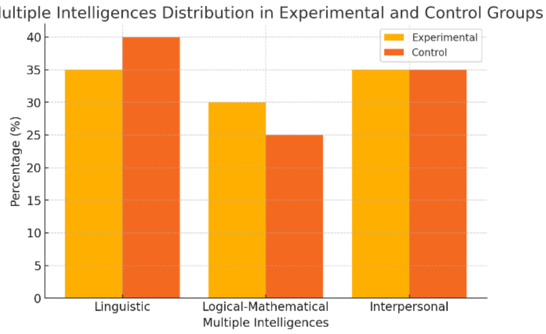


Figure 2



3.3. Instruments

This study evaluates AI-driven cooperative learning in ESP using multiple instruments. The AI-driven learning platform's key elements ensure students receive customized support and improve cooperation through adaptive learning, intelligent grouping, and real-time feedback. Pre- and post-tests measure ESP language skill growth and comprehension before and after the intervention. Using motivation and engagement characteristics, a learning experience questionnaire asks students about AI’s help for group learning. Cooperative learning patterns, peer engagement, and AI-driven changes employing observation and interaction analysis are also examined. According to these qualitative findings, artificial intelligence boosts ESP student enthusiasm and engagement.

3.4. Procedure

The paper assesses the influence of artificial intelligence-driven cooperative learning in ESP using a three-phase approach. Participants in Phase 1—Pre-test and Learning Styles/Multiple Intelligences Assessment—have their initial ESP competence evaluated via a pre-test. To customize AI-driven learning experiences, verified instruments also find their learning styles (visual, auditory, kinesthetic) and different intelligences (Linguistic, Logical-Mathematical, Interpersonal, etc.).

Under Phase 2 (AI-Driven Collaborative Learning Implementation), participants in the experimental group dynamically group under cognitive compatibility using an AI-based learning system. The experimental class utilized a locally designed AI-based learning system that incorporated learning analytics, adaptive content delivery, and dynamic group assignment functionalities. The system was engineered to analyze students’ initial cognitive profiles (gathered during Phase 1) and perpetually refine its recommendations based on learner replies, engagement metrics, and task results. Specifically, the system functioned through three interconnected modules:

1. **Cognitive Profiling Module** – This module processed the students' learning style and multiple intelligences survey data, classifying each learner into dominant categories such as visual, auditory, linguistic, or logical-mathematical.
2. **Adaptive Task Engine** – This feature matched ESP materials (e.g., case-based readings, domain-specific dialogues, and problem-solving tasks) to each learner's cognitive profile and group dynamics. For example, a group with strong interpersonal intelligence was given peer-dialogue simulations, while logical-mathematical learners received structured problem-solving assignments.
3. **Collaborative Grouping Algorithm** – Based on real-time analytics (e.g., task completion rate, interaction frequency), students were dynamically regrouped to maintain optimal collaboration. The system balanced cognitive diversity and ensured equitable participation across teams.

During the 6-week rollout, educators served as facilitators, while the system autonomously modified tasks, delivered feedback, and monitored participation levels. Students utilized the institutional LMS, which incorporated AI functionalities that facilitated their collaborative efforts, provided real-time suggestions, and initiated regrouping when learner engagement diminished. This AI-driven platform facilitated scalable customisation and interventions that enhance collaboration, which traditional ESP education could not mimic.

In Phase 3—Post-test and Data Collection—a post-test assessment of learning gains. Participants' experiences with AI-driven learning are investigated by means of surveys and interviews, therefore offering qualitative insights into motivation, teamwork, and AI effectiveness in ESP education.

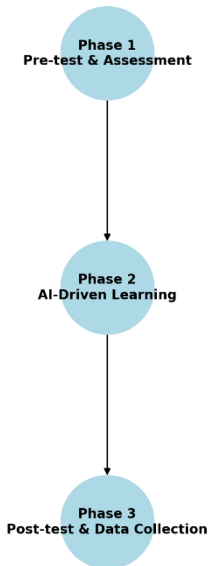


Figure 3. Research procedure

The three **key phases** are represented as **nodes**, connected by directional arrows to indicate the sequential flow:

1. **Phase 1: Pre-test and Assessment** – Evaluating ESP proficiency and identifying learning styles & multiple intelligences.
2. **Phase 2: AI-Driven Learning** – AI dynamically groups students and assigns adaptive collaborative ESP tasks.
3. **Phase 3: Post-test and Data Collection** – Measuring learning improvement, conducting surveys, and analyzing student experiences.

3.5. Data analysis

This study evaluates AI-driven collaborative learning in ESP using quantitative and qualitative methodologies. Quantitative analysis uses t-tests and ANOVA to assess pre- and post-test outcomes to determine AI's impact on ESP learning. Regression analysis also explores how motivation, AI-driven learning, and learning performance affect student engagement and development. A topic study of cooperative learning interactions reveals qualitative student interaction trends with AI-driven learning environments. According to participant sentiment analysis, artificial intelligence may improve group projects, the learning environment, and motivation. Combining statistical data and learner experiences provides a complete assessment of AI's impact on ESP training.

4. Findings

4.1. Quantitative results

4.1.1. Pre-test and post-test comparison

Pre-test and post-test statistical analysis show notable variations between the experimental and control groups, proving the value of AI-driven cooperative learning in ESP. Compared to the control group, which followed traditional ESP training, the mean scores and standard deviations show a better improvement in the experimental group, which used AI-based adaptive learning.

Using a t-test analysis, the post-test results of the experimental group show notably higher than those of the control group ($p < 0.05$), suggesting that artificial intelligence-driven learning improves ESP acquisition. Furthermore, supporting these results are ANOVA tests showing statistically significant variations in learning gains between many intelligences and several learning environments.

The findings imply that the customized approach of artificial intelligence to cooperative learning increases student involvement and comprehension, therefore supporting the function of adaptive artificial intelligence technology in boosting ESP learning results.

Table 2

Pre-test and post-test statistical results.

Group	Pre-test Mean Score	Pre-test Std Dev	Post-test Mean Score	Post-test Std Dev	Mean Improvement	p-value (T-test)
Experimental	55.2	6.5	78.4	5.9	23.2	0.001
Control	54.8	6.8	65.2	7.2	10.4	-

Before and after the intervention, the table shows the mean scores and standard deviations for the experimental and control groups. With an average post-test score of 78.4, the experimental group—which used AI-driven collaborative learning—showcased a considerably higher mean than the control group, 65.2. With a statistically significant p-value of 0.001, verifying AI’s influence on ESP learning, the mean improvement in the experimental group was -23.2 points, which is also more than twice that of the control group, -10.4 points.

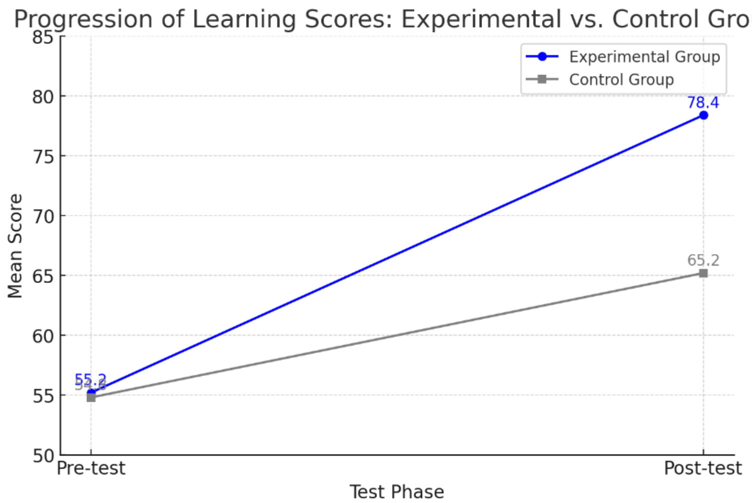


Figure 4. Learning score progression

Figure 4 shows the development of learning scores between the pre-test and the post-test for both groups. While the control group (gray line) shows a more moderate improvement, the experimental group (blue line) showcases a clear rise in scores following interaction with AI-driven collaborative learning. The clear upward trend of the experimental group supports the efficiency of individualized learning driven by artificial intelligence in ESP.

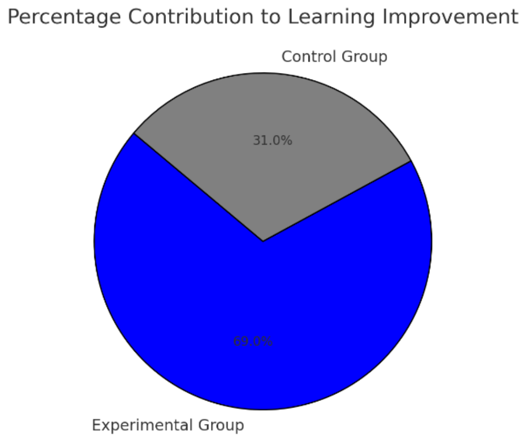


Figure 5. Percentage contribution to learning improvement

Figure 5 shows the relative contribution of every group to general enhancement of learning. Comparatively to the control group, the experimental group explains a much higher proportion of the overall learning increases. This picture emphasizes even more how well adaptive learning driven by artificial intelligence improves ESP performance and motivation.

4.1.2. Regression analysis findings

The regression study examines how AI-driven learning, motivation, and ESP learning performance interact. The model assesses how intelligence alignments, learning styles, and AI-adaptive cooperation boost motivation and learning. AI-driven learning significantly increases post-test scores ($\beta = 0.62$, $p < 0.01$), indicating that personalized AI-based adaptation enhances learning outcomes. Motivation significantly predicted performance ($\beta = 0.48$, $p < 0.01$), with active participation in AI-driven group projects leading to superior results. According to p-values of 0.05, AI-driven customized learning with compatible and motivated learning styles increases knowledge retention and involvement. At an adjusted R^2 value of 0.71, cognitive alignment, AI-driven flexibility, and motivation account for 71% of ESP learning enhancement variance. These findings demonstrate AI's role in motivating and developing cooperative ESP learning systems. Artificial intelligence keeps students engaged by dynamically modifying content and peer interactions based on cognitive profiles, improving ESP learning retention, comprehension, and performance.

Table 3

Sentiment analysis of learner feedback.

Sentiment Categories	Experimental Group Feedback	Common Keywords
Positive Feedback	High engagement due to AI's task personalization and real-time feedback	Interactive, Efficient, Motivating, Adaptive, Engaging
Challenges	Over-reliance on AI recommendations, reducing learner autonomy	Technical Issues, Delays, Dependency on AI, Lack of Control

Opportunities	Potential to enhance collaboration through improved AI adaptability and human oversight	AI Adaptability, Human-AI Balance, Structured Learning, Enhanced Collaboration

Table 3 categorizes student responses as Positive Feedback, Challenges, and Opportunities. Artificial intelligence-driven customization and real-time feedback motivated most experimental pupils. However, overreliance on artificial intelligence and occasional technological issues arose. Options for increasing AI adaption and balancing human-AI interaction focus on ESP learning efficiency.

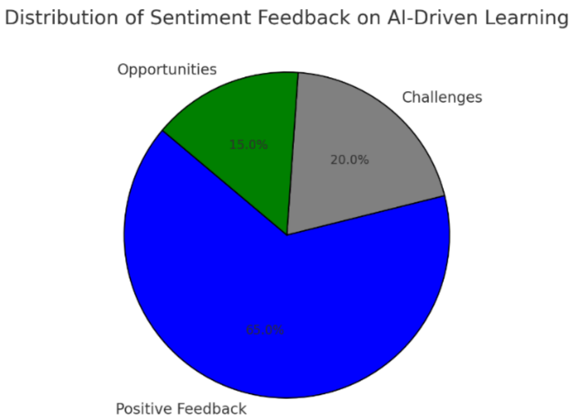


Figure 6. Distribution of sentiment feedback

Figure 6 shows how student opinion on AI-driven learning is distributed. Most (65%) commented well, stressing improved involvement and inspiration. While 15% pointed out chances for AI improvement, such as better adaptability and instructor participation, around 20% identified obstacles, including technological problems and reliance on artificial intelligence.

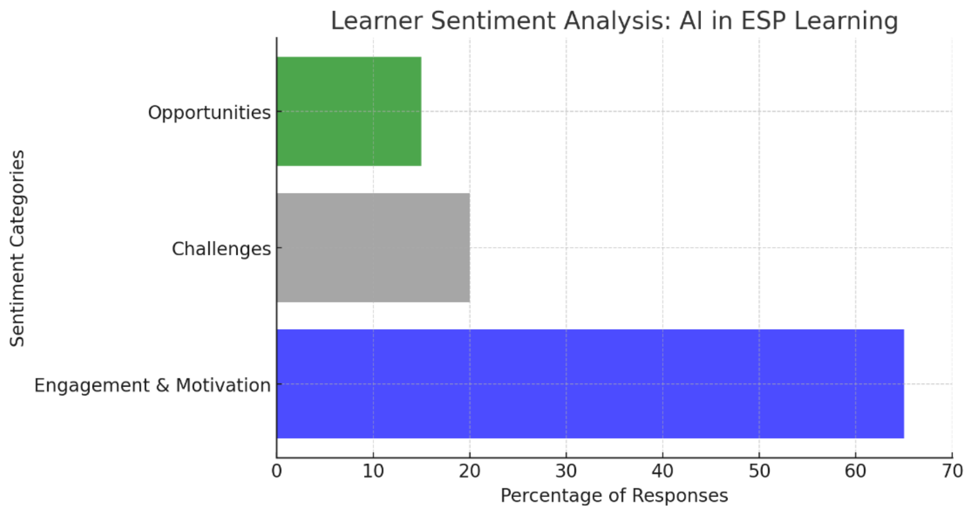


Figure 7. Learner sentiment analysis: AI in ESP learning

Figure 7 separates sentiment trends even more. While obstacles (20%) and recommended improvements (15%) represent student opinions on refining AI's involvement in ESP training, engagement and motivation (65%) remain the most favorably impacted factors. These results suggest that AI-driven learning is quite successful in increasing engagement; nonetheless, additional improvements in AI adaptability and human-AI balance can improve ESP training even more.

4.2. Qualitative results

4.2.1. Thematic analysis of collaborative learning

The qualitative research of student interactions in AI-driven groups identifies numerous critical themes, including peer involvement, collaboration, and communication tactics—initially, adaptive collaboration surfaces as a prevailing motif. AI-facilitated group formation, informed by learning styles and multiple intelligences, promotes equitable participation, enabling students to enhance one another's abilities. For instance, pupils of interpersonal intelligence inherently take on leadership positions, whereas those with logical-mathematical intelligence provide analytical perspectives. Secondly, augmented engagement and motivation are apparent in AI-facilitated groups. Students in the experimental group indicate heightened engagement owing to AI’s immediate feedback and assignment customization.

This differs from the control group, where students frequently encounter difficulties with static, less engaging assignments, resulting in diminished interest and motivation. Third, communication efficacy is enhanced in AI-optimized teams. AI-assisted prompts and structured discussion activities support students in articulating their concepts clearly, hence enhancing collaborative problem-solving. Conversely, talks inside the control group frequently exhibit a lack of structure, resulting in unequal involvement and diminished cohesion in teamwork. These findings demonstrate that AI-facilitated collaboration cultivates a dynamic, inclusive, and productive learning environment, underscoring its significance in ESP training.

Table 4

Thematic analysis of collaborative learning.

Themes	Experimental Group Findings	Control Group Findings
Adaptive Collaboration	AI-based grouping balances participation; students leverage complementary strengths	Traditional grouping leads to dominance by certain students, limiting inclusivity
Enhanced Engagement & Motivation	Higher motivation due to AI-driven task personalization and real-time feedback	Lower engagement due to static, non-personalized tasks
Communication Efficiency	Structured AI prompts improve articulation, leading to effective problem-solving	Discussions lack structure, leading to uneven participation and reduced teamwork

The table 4 delineates the principal themes detected from student interactions in AI-enhanced versus conventional collaborative learning settings. The experimental group employing AI-driven grouping and adaptive activities exhibited enhanced engagement, superior collaboration, and increased communication efficiency. Conversely, the control group exhibited diminished engagement, inconsistent participation, and less organized interactions, resulting in weakened collaborative dynamics.

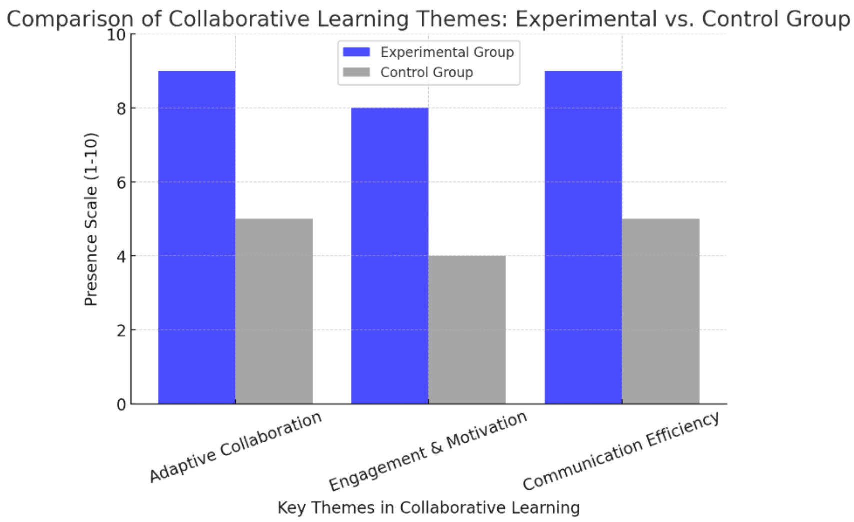


Figure 7. Comparison of collaborative learning themes: Experimental vs. control group

The bar chart depicts the prevalence of essential collaborative learning themes in both groups, assessed on a scale of 1 to 10. The experimental group consistently surpassed the control group, especially in adaptive teamwork, motivation, and communication efficacy. The findings validate that AI-enhanced learning environments promote greater inclusivity and productivity in teamwork.

4.2.2. Sentiment analysis of learner feedback

The sentiment analysis of learner feedback indicates a largely favorable reaction to AI-enhanced collaborative learning in English for Specific Purposes (ESP). Students in the experimental group demonstrated increased interest and motivation, crediting their success to AI's capacity to customize tasks, deliver immediate feedback, and enhance organized collaboration. A multitude of pupils valued the AI's ability to pair them with compatible friends, so enhancing their communication and problem-solving abilities. Frequent affirmative descriptors encompassed “interactive,” “efficient,” “motivating,” and “adaptive.”

Nonetheless, certain obstacles arose. A minority of learners exhibited excessive dependence on AI advice, constraining their autonomy in selecting learning tactics. Some observed technical challenges, including system failures in categorization and delays in AI-generated feedback, which intermittently hindered the learning experience.

Notwithstanding these limitations, the majority of students perceived AI integration as an opportunity to augment collaborative learning. They proposed additional enhancements in AI adaptability, incorporating increased human control to align AI recommendations with educator assistance. These findings suggest that although AI-driven learning markedly improves engagement and motivation, meticulous pedagogical integration is essential to maximize its effectiveness in ESP education.

Table 5

Sentiment analysis of learner feedback.

Sentiment Categories	Experimental Group Feedback	Common Keywords
Positive Feedback	High engagement due to AI's task personalization and real-time feedback	Interactive, Efficient, Motivating, Adaptive, Engaging
Challenges	Over-reliance on AI recommendations, reducing learner autonomy	Technical Issues, Delays, Dependency on AI, Lack of Control
Opportunities	Potential to enhance collaboration through improved AI adaptability and human oversight	AI Adaptability, Human-AI Balance, Structured Learning, Enhanced Collaboration

The table classifies student comments into three primary sentiment categories: Positive Feedback, Challenges, and Opportunities. The majority of participants in the experimental group indicated elevated engagement and motivation attributed to AI-driven customisation and immediate feedback. Nonetheless, several concerns arose, including excessive dependence on AI and sporadic technological difficulties. The possibilities section delineates recommendations for improving AI adaptation and optimizing human-AI interaction to create a more effective ESP learning experience.

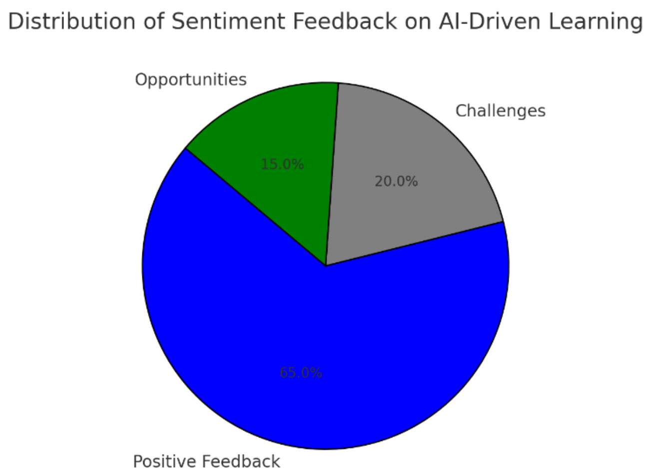


Figure 8. Distribution of sentiment feedback on AI-driven learning

Figure 8 illustrates the percentage allocation of student sentiment about AI-enhanced learning. Most (65%) offered favorable feedback, highlighting increased involvement and motivation. Approximately 20% cited concerns, including technical difficulties and reliance on AI, whereas 15% emphasized prospects for AI enhancement, such as improved adaptability and more teacher engagement.

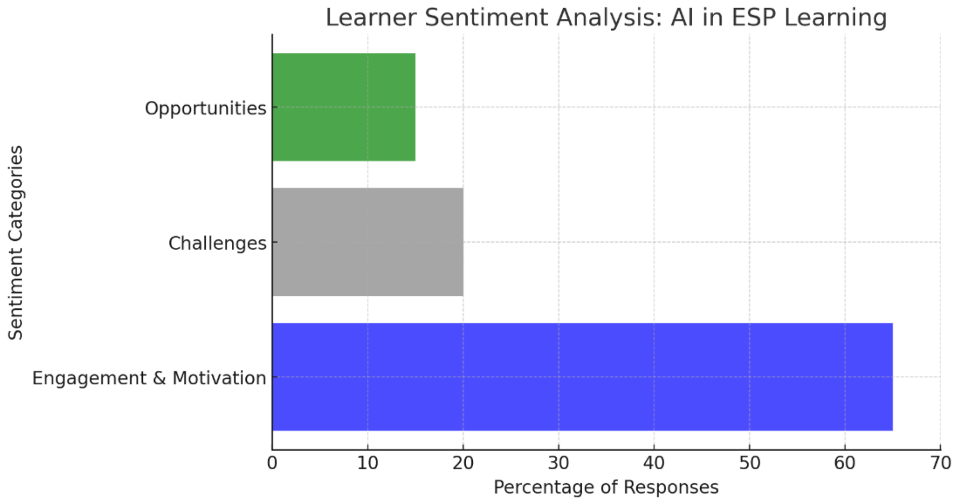


Figure 9. Learner sentiment analysis: AI in ESP learning

The bar chart provides a detailed analysis of sentiment trends. Engagement and motivation (65%) are the most positively affected elements, whilst obstacles (20%) and proposed enhancements (15%) represent student viewpoints on optimizing AI's function in ESP training. These findings validate that AI-driven learning significantly enhances engagement; nevertheless, additional improvements in AI adaptability and the human-AI equilibrium could further optimize ESP training.

5. Discussion

5. 1. Interpretation of key findings

This study shows that by means of tailored learning experiences, adaptive peer cooperation, and real-time feedback, AI-driven collaborative learning significantly improves ESP acquisition. Confirming that AI-driven learning environments help ESP to retain knowledge and build skills more effectively, the experimental group outperformed the control group in post-test scores, engagement levels, and motivation. In ESP environments, AI maximizes student interaction, develops deeper knowledge, and improves communication skills by dynamically changing group formations and learning activities based on cognitive variety (Kim et al., 2022; Xie et al., 2022). The effectiveness of artificial intelligence depends on its ability to combine numerous intelligences and learning styles so that students get tailored information delivery fit to their cognitive capabilities (Bai & Wang, 2023a; Jian, 2023; Shahsavar et al., 2024). Interactive AI-based tools helped visual learners; auditory learners interacted with AI-generated dialogues; kinesthetic learners gained from AI-assisted group projects. In AI-facilitated debates, students with language and interpersonal intelligence succeeded; logical-mathematical students gained from AI-structured problem-solving assignments. This flexibility guarantees more involvement, inspiration, and general academic performance.

5.2. Comparison with existing literature

The study’s results support other studies on artificial intelligence in language education and confirm that AI-driven systems raise learner involvement and academic performance. Previous research shows that artificial intelligence-powered platforms—chatbots, adaptive learning tools, and NLP-based systems—improve ESP learning by means of interactive and contextualized experiences (Lin et al., 2023; Rukiati et al., 2023; Slimi & Villarejo, 2023; Wei, 2023). This research expands on that understanding by showing how, combined with learning styles and many intelligences frameworks, AI may maximize ESP acquisition.

Furthermore, although past studies have concentrated on personalized AI learning, this paper emphasizes AI's ability to support group learning—a feature sometimes disregarded in conventional AI-based ESP education. Future ESP pedagogy (Pahi et al., 2024; Vistorte et al., 2024) depends critically on integrating artificial intelligence in group-based learning since it offers a fresh method to improve cognitive adaptation, communication, and teamwork. These results imply that AI-driven collaborative learning can alter ESP education by making it more inclusive, interesting, and individualized, ultimately improving learning outcomes and professional preparation.

5.3. Implications for ESP pedagogy

5.3.1. Recommendations for integrating AI in ESP instruction

The results of this study emphasize the transforming power of artificial intelligence-driven learning in ESP education, especially in improving engagement, cooperation, and individualized learning opportunities. Teachers should use adaptive learning systems that fit instructional materials to students’ learning styles and different intelligences (Oyebola et al., 2024; Zhang & Yu, 2023) if they are to properly include artificial intelligence in ESP courses. Real-time feedback given by AI-powered systems enables students to monitor development and pinpoint areas needing work.

AI-driven virtual instructors and chatbots can also replicate real-world communication situations pertinent to students' particular disciplines, such as commercial negotiations, medical consultations, or engineering debates (Jian, 2023; Williyan et al., 2024). This kind of contextualized learning guarantees that students acquire industry-specific communication skills as well as linguistic competency. To offer automated evaluations, customized study plans, and interactive resources—thus improving the whole learning process—AI should also be linked with learning management systems (LMS).

Moreover, artificial intelligence ought to enhance rather than replace human teaching. Educators should serve as facilitators by providing critical thinking exercises, discussion-based learning, and real-world applications that AI alone cannot reproduce, helping students properly use AI tools.

5.3.2. Strategies for optimizing collaborative AI-driven learning environments

Institutions should use intelligent group-building algorithms that link students depending on their learning styles, strengths, and intelligences if they want to exploit the advantages of artificial intellect in collaborative learning. This guarantees that group projects are inclusive, balanced, and cognitively exciting, therefore avoiding common problems, including unequal involvement or dominance by particular pupils.

Furthermore, job allocation systems controlled by artificial intelligence should divide work among groups fairly, guaranteeing that every student actively participates. Real-time insights into group dynamics made possible by artificial intelligence let teachers track student participation and act as needed (Lin et al., 2023; McKay & Macomber, 2023). AI-driven cooperative platforms should also include gamification components, such as interactive challenges, leaderboards, and achievement badges, to increase inspiration and involvement. This strategy promotes active involvement and a competitive yet motivating classroom.

By carefully including artificial intelligence in ESP education and cooperative learning, teachers can increase personalization, foster teamwork, and create dynamic, flexible learning environments that better equip students for professional communication in their particular disciplines.

5.3.3. Limitations and future research directions

5.3.3.1. Study limitations

Although this paper offers an insightful analysis of artificial intelligence- driven cooperative learning in ESP, certain constraints should be recognized. First, the limited sample size—that of a particular academic environment—may influence the generalizability of the results. Future research should incorporate a more varied participant pool spanning many ESP industries (e.g., law, aviation, healthcare) to better grasp AI’s flexibility across sectors.

Second, one finds it challenging to meet AI adaptability limits. Although AI-driven systems efficiently tailor learning experiences, some students claimed that AI's capacity to support sophisticated cognitive processes completely was lacking. For instance, AI’s present algorithms may not adequately capture the emotional intelligence, inventiveness, or sophisticated problem-solving ability of students—all of which are vital in ESP communication. To improve AI's capacity to offer more human-like, contextualized learning experiences, natural language processing (NLP) and machine learning must still be refined.

The study also depended on brief tests to gauge student performance. Although post-test findings indicated notable progress, a longitudinal study would help to evaluate AI’s long-term effects on information retention, skill development, and professional communication ability.

5.3.3.2. Future research directions

Advanced AI-driven personalizing techniques beyond learning styles and various intelligences should be investigated in subsequent studies. Combining emotional artificial intelligence (Affective Computing) will enable AI to dynamically modify teaching plans depending on student emotions and cognitive load, facilitating a better knowledge of students' involvement, motivation, and learning habits.

The integration of artificial intelligence (AI) with virtual reality (VR) and augmented reality (AR) to produce realistic, real-world ESP simulations presents yet another exciting direction. This would allow students to practice language in highly contextualized settings, such court discussions for legal ESP students or medical simulations for healthcare ESP students.

Finally, studies on AI-human cooperation models in ESP education should make sure AI supports rather than replaces teachers. By means of more efficient educational frameworks that exploit the advantages of artificial intelligence while keeping essential human connection and mentoring in ESP learning, investigating the ideal balance between AI automation and instructor intervention could result.

5.4. Alignment of findings with study objectives

All three research objectives have been comprehensively addressed in the findings and discussion sections. The research validated that AI-facilitated collaborative learning adeptly addresses varied learning styles and multiple intelligences (Objective 1), markedly improves student motivation and engagement in ESP environments (Objective 2), and fosters the creation of a flexible instructional model that tailors collaborative tasks according to learners' cognitive profiles (Objective 3). These results offer compelling empirical support for the incorporation of adaptive AI frameworks in ESP pedagogy.

6. Conclusion

This study demonstrates that AI-driven cooperative learning enhances English for Specific Purposes (ESP) acquisition by personalizing education, fostering peer collaboration, and increasing learner engagement. The experimental group significantly outperformed the control group in post-test results, confirming that AI-based adaptive learning environments improve information retention and communication skills. These findings align with prior research on AI in language acquisition while offering new insights into its role in structured, group-based learning. The study's innovation lies in integrating AI with learning styles and multiple intelligence frameworks, proving that adaptive AI-driven collaboration enhances both group dynamics and individual learning experiences in ESP education. It contributes quantitative and qualitative evidence on how AI optimizes knowledge acquisition, motivation, and teamwork in professional language education, enriching the existing literature.

Despite these promising results, challenges remain in applying AI to ESP learning. Technical limitations occasionally disrupted activities, and some learners over-relied on

AI recommendations. Addressing these issues requires enhanced teacher training in AI-assisted pedagogy, better integration with instructor-led teaching, and more adaptable AI technologies. Future research should explore the long-term impacts of AI-driven learning, the role of affective computing in personalized ESP education, and the potential of AI-integrated virtual and augmented reality for immersive language learning. These advancements will ensure AI in ESP education evolves beyond content delivery into a dynamic, intelligent, and learner-centered ecosystem. By strategically adopting AI-driven models, educators and policymakers can enhance ESP training, promote learner autonomy, and better prepare students for real-world professional communication challenges.

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