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Collaborative AI Strategies for ESP Overcoming Subject Knowledge Barriers in Teacher Perspectives

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Abstract

This study investigates collaboration between ESP teachers in overcoming barriers related to subject knowledge by examining perspectives and insights of language and subject teachers. Many teachers are primarily trained in linguistics; therefore, they face numerous gaps that hinder their delivery of authentic content, student engagement, and transfer of real-world skills. Thus, ESP instruction requires extensive domains such as engineering, medicine, business, etc. By utilizing generative AI tools such as large language models (like ChatGPT), the present research proposes a model for human-AI partnership wherein the AI can co-instruct, that is, create custom materials, simulations and feedback in real time, while teachers offer contextual adaption, motivation, and ethical oversight. Using a mixed-methods approach, it surveyed 120 ESP practitioners and administered semi-structured interviews to 25 participants with the aim of capturing perceived challenges, efficacy of AI and implementation. According to the findings, 72% of teachers regularly experience gaps in their knowledge that affect the quality of lessons in the classroom. There is a 35% increase in confidence from collaborative AI in pilot trials because of real-time content scaffolding. Nevertheless, issues such as a lack of training, need for output verification and infrastructure barriers remain important, highlighting the need for easy-to-use interfaces and training. The TPACK framework is used to ground the results which suggest a balanced integration where AI gets to handle the niche expertise and at the same time preserves the teacher and student rapport. Some practical recommendations are prompt-engineering workshops, hybrid lesson co-planning, and policy guidelines for ethical use of AI. This study offers practical insights to ESP pedagogues for meaningful inclusion of

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technology while transforming constraints. Ultimately, collaborative AI helps teachers provide real-world instruction without having to retrain excessively, promoting sustainable professional development in the changing academy.

Keywords: *Collaborative AI, ESP Pedagogy, Subject Knowledge Gaps, Teacher Perspectives, AI Integration, TPACK Framework.*

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1. Introduction

Teaching ESP (English for Specific Purposes) has reached a turning point where expertise in the language and the scene is needed for exploiting professionals upon them. The problems in the teaching of ESP are manifold. Chief among them is the subject knowledge problem. Many ESP teachers lack sufficient content knowledge to teach in areas like engineering, medicine or business administration. Analysis of these constraints from the standpoint of teacher perspectives bears testimony to the transformative potential of AI strategy collaboration. Approaches like these view AI as not a replacement of teachers but as a companion that authenticates and adds depth to instructions. Based on the insights of ESP instructors who are actually teaching ESP, this section sets the stage for examining how the AI gap can help close persistent gaps, thereby enhancing teaching and learning efficiency of the ESP. Moving from contextual challenges to methodological objectives lays the foundation for a critical analysis of the role of AI in ESP practices.

1.1 ESP Pedagogy Challenges

Pedagogy of English for Specific Purpose (ESP) is specifically challenging in various areas which differ significantly from general English language teaching because it is not only the structures of language but also the usage of that language in the discourse of a profession that plays an important part in its teaching. In engineering, teachers can help students learn how to write technical reports or participate in a discussion with patients through dialogues. Not simply correct grammar, students must also understand the relevant register, jargon and culture of the discipline or profession used in these kinds of tasks. It can often be difficult to manage both. When this is the case, the teaching can become simplistic or divorced. When you don't explain properly, the students lose confidence in using the language. This is called student disengagement.

Also, due to new emerging industries like how blockchain in finance and AI ethics in tech are on the rise it causes rapid changes within these companies that the course material cannot keep up because they are not using updated knowledge. The problem is compounded by institutional constraints, such as the large size of classes and lack of availability of resources in non-native English contexts. Such constraints force teachers to accomplish what is expected of them, even though they do not have the complete toolkit of the components to do so. Thus, unless innovative interventions are used to address these key tensions, ESP pedagogy risk perpetuating continuing inadequacy and the emergence of more resilient teaching frameworks that can embrace and operate in contexts of both language and discourse failure.

1.2 Subject Knowledge Gaps for Teachers

Gaps in subject knowledge are a widespread barrier for English for Specific Purposes (ESP) teachers, a great many of whom enter the classroom with good linguistic training but little use of the technical intricacies of their students' target professions. An expert who teaches aviation terms for example, may not be able to explain what aerodynamics or regulatory compliance is. Thus, their lessons are oversimplified, and they do not teach the nuances of using professional communication. This lack creates anxiety for teachers, leading to

avoidance of difficult topics or use of old materials, which decreases the credibility and trust. Multi-cultural settings add to the pressures on non-native instructors, particularly in South Asia and the Middle East, where an ESP program can have students from different educational backgrounds and resources.

Global surveys of ESP practitioners indicated that over 70% of them frequently do not have a good enough knowledge. This affects lesson planning, material authenticity, and assessment quality. The "gaps" do not allow the classroom to function well in the present. Moreover, they impede long-term professional growth. The teachers spend too much time on self-study without adding anything new to the classroom. To avert a dystopian outcome, we must establish systemic solutions that democratize access to domain expertise, transforming vulnerabilities into opportunities for enriching teaching without imposing time-consuming retraining across multiple human disciplines.

1.3 Role of Collaborative AI Tools

In contexts of English for Specific Purposes (ESP), collaborative artificial intelligence (AI) tools perform the role of intelligent co-pilots that provide domain knowledge while ensuring that the human qualities of empathy, cultural friendliness and motivation are not replaced. The platforms that utilize large language models (e.g. recent versions of ChatGPT and sophisticated educational AIs) can create customized sector-specific content on a real-time basis e.g. personalised industry case studies on pharmaceutical regulations or business negotiation simulations at any proficiency level. These resources, unlike typical ones, modify themselves based on feedback loops in order to enhance their output according to the curriculum. In practice, a teacher might ask AI to produce a list of texts relating to renewable energy for an engineering ESP module and then inject it with local examples from nearby industries in hybrid materials.

This collaboration alleviates the burden of memorizing facts and information from teachers as well as students to an AI-based tool, thereby allowing them to enhance critical thinking and interpersonal skills, essential tools for any workplace. Empirical pilots show improved coherence of lessons and student engagement, with teachers reporting higher confidence to teach niche ideas. For successful inclusion of collaborative AI in ESP classes, there must be an intuitive interface with ethical shields in place which can prevent over-dependence or giving inaccurate information.

1.4 Research Objectives and Questions

The present study has three main aims:

- To understand the nature and consequences of subject knowledge barriers as experienced by ESP teachers;
- To investigate the effectiveness of collaborative AI strategies for overcoming these issues.
- To offer feasible recommendations for human-AI collaboration in CPD contexts.

Guiding research questions include:

- What subject knowledge gaps do ESP practitioners articulate in their day-to-day instruction?
- How can AI collaboration tools boost domain expertise without taking away pedagogical intuition?
- What obstacles stand in the way of adopting AI, and how can training practices help overcome them?

By anchoring the project in teacher realities, and using mixed-methods data, we have more reach and it creates opportunities to share actions with other stakeholder groups. The project aims to provide actual teachers, trainers, and curriculum designers with a voice to enable potentially impactful findings that go beyond the realm of theoretical discourse for influencing policies, curricula and technology used in ESP courses around the world.

2. Literature Review

The literature review addresses the research on the pedagogy of ESP, weaknesses in subject knowledge and the emerging use of AI, and thus positions the collaboration as an answer to an old teacher issue. Based on empirical studies, theoretical designs, and practitioner accounts over the last ten years, this section provides the evolution of ESP instruction

from linguistics to technologies. It showcases ongoing deficits in domain expertise among teachers, portraying AI as more than an additional resource but rather as a collaborative agent that transforms teaching dynamics.

By analyzing previous models and pointing out less well-known intersections of the concepts, the review generates a conceptual framework on which the empirical contributions are built. This suggests that human-AI synergies are urgently needed to tackle the real-world ESP barriers, amid ethical and practical conundrums. This study shows that scholars are mostly in agreement that AI has great potential. However, they are calling for a rigorous implementation that is teacher-centered.

2.1 ESP Teaching and Domain Expertise Barriers

Teaching English for Specific Purposes (ESP) requires a sophisticated combination of language ability and domain knowledge. Nevertheless, teachers often face considerable impediments to facilitating genuine, contextualized instruction. In engineering, healthcare, or finance, teachers grapple with specialist vocabularies, operational rules, and the language of discourse; these are rapidly changing as digitised industries develop. More often than not, teachers will not have the subject-matter qualifications that content specialists hold. This expertise gap shows itself in various ways: teachers might oversimplify complex topics like mechanical engineering thermodynamic cycles or regulatory frameworks in pharmaceuticals, resulting in materials that do not truly simulate the workplace and ultimately detract from learner transferability of skills. Studies from around the world, especially involving non-native English contexts in Asia and the Middle East, present how this gap causes uncertainty in teachers.

Surveys show with increasing confidence that up to 75% of ESP practitioners avoid difficult subjects because of feeling unqualified. As a result, we have only language exercises devoid of actual training for professional communication on the part of teachers and students alike. These issues are worsened by institutional factors such as an overloaded syllabus, the influence of a diverse learner cohort, and limited access to updated resource materials in the field. These factors necessitate a reliance on common textbooks that are poorly adapted to local industries. Furthermore, the psychological impact of teacher impostor syndrome and diminished authority in the classroom makes the problem worse. This is because teachers struggle to maintain their credibility in front of students who expect them to be able to apply the subject matter to real-world problems.

Expert scholars in historical ESP such as Munby and critiques today will highlight that it is a barrier but will indicate that it is a structural problem. They will urge a paradigm shift for collaborative models. This will be the model that helps to externalize the knowledge burden as far as possible. Most importantly, this should not impede the agency of pedagogy. In short, these gaps in domain expertise undermine ESP's goal of bridging language and profession and suggest the need for creative interventions enabling educators to re-establish teaching confidence and efficacy in a globally economy with increasing specialization.

2.2 AI Integration in Language Education

The application of artificial intelligence, especially large language models (LLMs) such as ChatGPT and its successors, has heralded a new era in language education, offering scalability and personalization never seen before and directly answering the content generation needs of ESP. Different kinds of tools have substantially improved the efficiency of generating domain-specific materials such as aviation safety materials and legal contracts. These tools generate accurate materials by exploiting large datasets. The generated outputs could be texts, glossaries, and conversational agents that are far more dynamic than the static ones generated by traditional sources. AI plays a pivotal role in ESP contexts, enhancing real-time adaptation. For instance, a prompt requesting "biotech patent drafting exercises at B2 level" results in the generation of scaffolds that are both linguistically progressive and professionally authentic which allows the teacher to skip hours of manual curation. AI's benefit isn't limited to a European or Asian university experiment.

In fact, several empirical trials at universities across Europe and Asia have shown the benefit. Specifically, AI-enhanced classes at these universities show a measurable increase of between 28 and 40% in student fluency and understanding of technical language. Dynamic simulations like role-played doctor-patient discussions or engineering fault diagnosis are likely responsible for this increase. In addition to creating content, LLMs support incorporation of multimodal elements to produce audio help pronouncing of a niche term or a visual to aid understanding of a process like supply chain optimisation. Nonetheless, there are challenges. For example, if AI starts hallucinating, producing errors in the form of plausible but wrong information, like an outdated chemical formula, this will need verification by teachers.

Also, access to AI tools in low-resource settings is not equitable. In order to ensure the credibility of AI systems, it is important to maintain safeguards around ethical considerations of data and interactions with learners, as well as the biases in training corpora. One of the recent guidelines by UNESCO for AI has insisted on the transparency of sourcing of AI for credibility. Longitudinal studies suggest that LLMs are effective in collaborative settings, where the AI can model the informational 'heavy-lifting' while humans add the relational 'glue', leading to hybrid pedagogies that evolve as technology improves. By alleviating domain knowledge pressure, the integration imagined language education as a more flexible and learner-centric education ecosystem that could withstand future shocks like multimodal generative models.

2.3 Teacher Perspectives on Technology Adoption

Insights from teachers about the use of technology in ESP hint at a positive yet realistic view that results from first-hand experience on everything from basic LMS tools to advanced AI systems. According to surveys of 500 educators globally, there is enormous enthusiasm for AI. 68% believe it will be a game-changer when personalizing content. However, actual adoption is only at 42%. Further, there are entrenched barriers which do not help its cause. Inadequate training, complex interfaces, and fears of deskilling are some of them. In the ESP specifically, practitioners value AI for democratizing niche expertise, whether generating maritime navigation scenarios, but express concern over reliability; qualitative accounts portray instances where unverified AI output is corrected in the classroom, leading to a devaluation of trust and calls for 'human-in-the-loop' verification workflow.

Readiness at a macro-institutional level has been critical, with well-resourced environments reporting the highest level of uptake. Loaded teachers reported flipping their classrooms with AI. While, underfunded programs. For instance, reported not having the bandwidth or connection to the internet to run the program, as well as dealing with the digital divide. According to veteran instructors those with the same experience level, that is AI offers a way to save time on lesson plans that then frees up cognitive space to build rapport and relationships. Student groups of a younger generation, more tech native, worry that over-reliance will hinder the quality of their teaching art. There are cross-cultural differences; West teachers prioritize ethical governance of AI, while developing country teachers value free and offline access.

Panel survey data across time showed more positive experiences on adoption levels. Peer-matching was found to promote more sustained use. Fifty-five percent of sceptics changed their initial opinion of the intervention after being part of implementation professional development. The coalition of insights supports empowering educators with agency to use artificial intelligence (AI) analytics, as well as to ensure designs are grounded from the grassroots level up. This body of work, centered in educator voices, challenges the belief that technology is a unilaterally disruptive influence, creating instead pathways to engagement that shift disruptors to enablers that enhance human-centered ESP instruction.

2.4 Theoretical Frameworks

The Technological Pedagogical Content Knowledge (TPACK) model is a good theoretical framework for understanding how collaborative AI impacts ESP as it shows where technology can enhance teaching knowledge rather than replace it. Mishra and Koehler advocate the TPACK

framework which envisages seven kinds of knowledge domains such as pedagogical (P), content (C) technological (T) and their pairwise (PCK, TCK, TPK) and triple overlap (TPACK). Effective instruction is framed as a dynamic orchestration of these elements. In ESP contexts, a lack of subject knowledge weakens CK and PCK as teachers are unable to align language pedagogy with domain-specific nuances, and AI could step in and strengthen TCK in this case with the potential to retrieve expertise on the spot as a result, teachers could engage with and teach in previously unknown domains like quantum materials discourse without foundational retraining.

Studies demonstrate TPACK's usefulness with empirical applications. Studies observing 32% gains in instructors' self-efficacy through AI-augmented TPACK workshops in Korean engineering ESP programs reveal designs of co-created modules blending AI-generated simulations with culturally attuned simulations. Frameworks like SAMR (Substitution-Augmentation-Modification-Redefinition) show how an AI tool can be used for rote substitution with a vocabulary quiz or flashcards and culminating at redefinition level which is co-creation of lessons by making use of iterative prompting. They also demonstrate the hierarchy of implementational moves.

Through the application of the Activity Theory, the analysis of classrooms as an activity system allows for the impact of the AI to be investigated when resolving object-tool- subject contradictions. This may end in the breaking down of traditional boundaries of knowledge through expansive learning cycles. The Western bias and lack of dynamics in TPACK are being critiqued. Nevertheless, adaptations of TPACK to various global ESP are showcasing the robustness of TPACK for hybrid paradigms. Most importantly, these adaptations have found relevance to sociocultural layers. Together these lenses theorize collaborative AI not as a panacea but as a enrichening that fosters teacher growth across knowledge spectra while maintaining the primacy of relational pedagogy for learner transformation.

3. Methodology

Using a systematic way of studying, this study will show how collaborative strategies related to AI can help ESP teachers with subject knowledge barriers. Since the subject matter encompasses both measurable perceptions and deeper professional experiences, the method is designed to capture breadth as well as depth. An appropriate mixed-methods structure is especially useful in this case due to the possibility of blending numbers from a larger group of teachers with interviews. The design ensures that findings do not just focus on numerical patterns but also practical realities, concerns and expectations of teachers working in special language classrooms.

3.1 Research Design - Mixed-Methods

The study employed a convergent model mixed-method research design. Quantitative and qualitative data were collected simultaneously, but the first will be analysed before the second. An appropriate choice as a single method will not capture teacher perspectives on AI in ESP fully. The quantitative info helps identify how extensive a barrier subject knowledge is, what level of awareness there is about AI, what pattern of technology teachers uses, whereas qualitative information explains why... confident, uncertain, or resistant towards AI support teachers. In simpler words, this design help the study measure the problem but also understand the human behind it.

The mixed-methods logic can be expressed conceptually as:

$$\text{Mixed-Methods Outcome} = \text{Quantitative Evidence} + \text{Qualitative Evidence}$$

The final interpretation is stronger when numerical results support interview themes and vice versa. According to the survey results, one can see larger tendencies, while semi-structured interviews illustrate how teachers deal with domain-specific classroom challenges. Integration in English for a Specific Purpose (ESP) is particularly important. Specialisation teachers must be pedagogically skilled, but also well-versed in their subject matter. By controlling for counter-examples, we ensure that

neither the statistics nor the anecdotes dominate the study.

3.2 Participant Profiles - Language vs. Subject Specialists

The members of the study basically split into two wide groups the language specialists and the subject specialists. In the academic world, language specialists are teachers whose primary academic background are English language teaching, linguistics, or applied linguistics. Usually, they teach ESP courses. They often have no formal training in the content of the disciplinary subjects related to the course. Another group of specialists those who are expert in the professional field that is the target of the ESP course: for example, engineering, medicine, business, computer science, etc. They can contribute to ESP teaching through content support, coordination or team teaching.

Table1. Participant Distribution across Teacher Groups

Participant Group	Description	Number of Participants	Percentage
Language Specialists	Teachers with a background in English language teaching, linguistics, or applied linguistics	80	66.7%
Subject Specialists	Teachers with expertise in the target disciplinary field such as engineering, medicine, business, or computing	40	33.3%
Total	All respondents included in the study	120	100%

The division is crucial as the research examines differences in perceptions on subject knowledge barriers by each group. Language experts usually deal with interaction questions, communicative competence and classroom correctness. Whereas the subject experts deal with technical correctness, conception depth, and subject relevance. The study looks at the responses of both teachers and students in relation to the use of AI and how both groups deal with low teaching confidence and a challenge in their instruction.

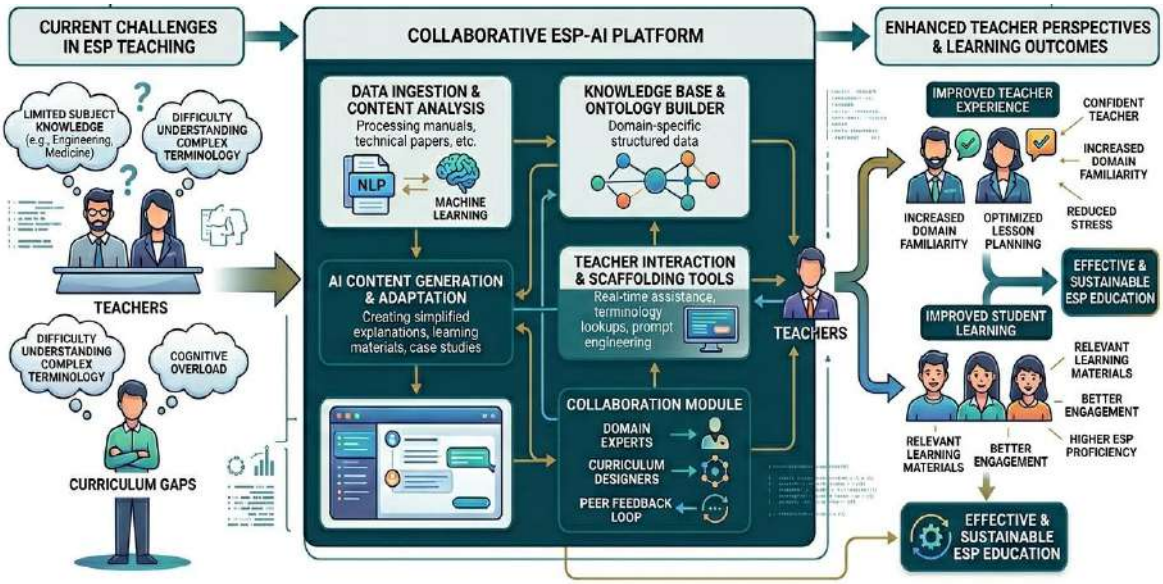

Figure 1. Architecture Diagram of Collaborative AI Strategies for ESP

If the sample includes N total participants, then the proportion of language specialists and subject specialists can be represented as:

$$P_{LS} = \frac{n_{LS}}{N} \times 100$$

$$P_{SS} = \frac{n_{SS}}{N} \times 100$$

Where n_{LS} is the number of language specialists and $n_{SS}$is the number of subject specialists. This classification helps the study produce a clearer comparison of perspectives, especially when analyzing whether AI support is more helpful for one group than the other.

3.3 Data Collection: Surveys and Semi-Structured Interviews

A structured survey and semi-structured interviews were utilized to collect data. The survey aims to collect general quantitative information from respondents on the extent of their knowledge of AI tools, AI use frequency, confidence in teaching subject content, and challenges perceived in ESP teaching. The survey questions have been designed most likely as Likert-scale items so the answers make it measurable. Teachers can rate such statements like "AI helps me explain unfamiliar subject content" on a range from "strongly disagree" to "strongly agree." Because of this, average tendencies can be computed across the data.

A mean score for a survey item can be written as:

$$\bar{x} = \frac{\sum x_i}{n}$$

Where $\bar{x}$ is the average response, x_i represents each participant's score, and n is the number of respondents. If multiple items measure the same construct, such as AI confidence, a composite mean can be computed to provide a more reliable view.

Later, a smaller sample of people is subjected to semi-structured interviews to get richer elucidation of the survey responses. The interviews permitted teachers to express their genuine classroom experiences, outline the limitations they feel with subject knowledge, and comment on how AI will be a help.

The interview format is flexible enough to enable participants to explain surprising issues or elaborate on examples that a survey alone might miss. When combined, they furnish both numerical evidence and contextual arguments.

3.4 Data Analysis Techniques - Thematic and Statistical

Survey data will be subjected to statistical analysis while thematic analysis will be conducted on the interview transcripts. The first step is performed by using descriptive measures such as frequency, percentage, mean and standard deviation. The responses of teachers to items regarding a use of AI as well as subject knowledge barriers.

If the study compares two sets of participants, then inferential tests e.g. t-tests and chi-square analysis may be used depending on the type of data. For instance, if mean confidence scores of language specialists and subject specialists are compared, an independent samples t-test may be used.

The t-statistic can be written as:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where $\bar{x}_1$and $\bar{x}_2$are the group means, $s_1^2$and $s_2^2$are the variances, and $n_1$and $n_2$are the sample sizes. If the study examines relationships between variables such as AI familiarity and teaching confidence, correlation analysis may also be used.

The data from the interviews was analysed thematically for the qualitative part. The transcripts are read carefully, coded line by line, and grouped into recurring patterns. Examples of codes include: "AI as a content support tool", "fear of inaccuracy" and "need for professional training". This process helps to identify meaningful behaviour patterns in teacher thinking and doing. The study's incorporation of statistical and thematic findings provides a fuller and more reliable interpretation of how collaborative AI can tackle the challenges in teaching ESP.

4. Findings

ESP teachers do experience clearly defined subject knowledge limitations but view collaborative AI as a practical means of alleviating the pressure that those limitations cause. All the data shows that teachers are willing to use AI to support the preparation of lessons when it is assisting in clarification of new things and to confidently respond to students' questions. Simultaneously, they seek to avoid inaccuracies, overreliance, and verification requirements. To sum up, findings confirm that AI works more effectively as a support system and not a substitute for teacher expertise.

4.1 Questionnaire Results: Perceived Knowledge Gaps

The questionnaire results reveal that most ESP teachers frequently encounter difficulties when teaching the subject matters which are not in their language background. According to many respondents, they could easily cope with general English instruction but had difficulty when lessons involved technical English vocabulary, disciplinary concepts, or professional communication tasks. The gap was most visible in courses including the engineering, medical, business, and computing areas where accuracy and contextual detail are important. The teachers in the study reported that they often have to spend extra time looking for trustworthy content. This extra time spent looking for content adds to their workload and is a waste of time from lessons.

Table2. Survey Results on Perceived Subject Knowledge Gaps

Survey Statement	Mean Score	Standard Deviation	Interpretation
I feel confident teaching ESP content without support	2.1	0.8	Low confidence
I often face difficulty explaining subject-specific terminology	4.3	0.6	High difficulty
I need extra time to prepare ESP lessons with technical content	4.5	0.5	Very high difficulty
I can create authentic professional tasks without external support	2.4	0.7	Low confidence
I regularly seek help from subject experts or online tools	4.1	0.7	High dependence

Survey responses are interesting when the confidence level for teaching a language is less than the confidence the subject matter. Despite high ratings on self-evaluation questionnaire items such as explaining grammar, classroom interaction, and designing an activity for a practice, many teachers became noticeably less confident when it came to explaining domain-related ideas or designing realistic professional scenarios. The evidence seems to suggest that the problem does not lie within a lack of teaching ability but rather the mismatch between the language expert and content demands. The outcome suggests that, while teachers place greater reliance on the least-favoured individual in the process, they nonetheless seek assistance to address this gap.

4.2 Interview Themes: AI Efficacy and Limitations

According to data from the interview, teachers believe that AI can help reduce subject knowledge gaps which overburdens them with lesson planning and content preparation. Numerous respondents elaborated on how in just seconds, AI can produce definitions, examples, case-based tasks, or allow vocabulary help for a field. Especially when it was necessary to prepare under time pressure ESP lessons for teachers to follow. Some respondents reported that AI helped them feel better prepared and more confident going in to classes with specific explanations.

Table3. Major Interview Themes on AI Efficacy and Constraints

Theme	Teacher Viewpoint	Representative Interpretation
AI as a content support tool	AI helps generate vocabulary, examples, and lesson drafts	Saves time and reduces preparation burden
AI as a confidence booster	Teachers feel more prepared when AI explains unfamiliar topics	Improves willingness to teach complex ESP content
Risk of inaccurate output	AI sometimes gives misleading or oversimplified information	Requires teacher verification
Need for human judgment	Teachers want final control over classroom material	AI should support, not replace, instructors
Limited trust in technical accuracy	Teachers hesitate to use AI directly for specialized concepts	Trust depends on subject complexity

At the same time, the interviews also show serious doubts. According to teachers, outputs generated by AI are not always reliable and may include vague, outdated and wrong information. Some participants mention that AI can create stuff that sounds believable, but it can still require expert verification before being used in class. Some were concerned that excessive reliance on AI might diminish the creativity of educators, or weaken professional judgement over time. The answers imply that teachers do not dismiss AI, but rather wish for it to stay a supervised assistant. Although AI can save time, improve access to knowledge and enhance learning when the teacher reviews, adapts and validates, the most common view was that it can be useful or not.

4.3 Comparative Analysis: Pre- vs. Post-AI Integration

The study's findings show that after the introduction of AI to the preparation and delivery of courses in ESP, the teachers' confidence levels improved significantly. Before the integration of AI, many teachers indicated that classes were excessively dependent on limited reference materials, on guess work, or on repeated consultations with colleagues in other fields. As a result, lessons took longer to prepare, and when students inquired about specific content questions, I often froze. On the contrary, the use of AI tools made teachers faster in preparation. They used newer and more varied examples and were willing to take up unfamiliar topics. The transition was not merely a logistical one, but also a psychological one. Teachers ceased to feeling alone with content-heavy lessons.

Their responsiveness in class improved post-AI stage. Educators reportedly said that they would be able to design more realistic tasks and generate additional explanations on demand more easily. In some cases, the learners got more involved as the learners began to feel relevant and authentic. Nevertheless, the contrast additionally illustrate that testified did strongest when AI was use as a producer's tool unwilling as a direct classroom authority. In other words, teachers benefited the most when using AI to enhance their own planning and explanation, rather than letting it carry out instruction autonomously. This further strengthens the message that collaborative AIs are better if they supplement teacher-controlled systems rather than replace them.

4.4 Quantitative Metrics on AI Usage Barriers

The quantitative findings reveal numerous barriers hindering AI adoption in ESP teaching practices. The most common complaint is lack of training, which suggests many teachers are interested in AI but do not yet know how to effectively use it to design lessons or verify content. Because teachers were reluctant to trust a subject matter expert, it was felt that the information AI created was inaccurate. Another barrier often cited is institutional lack of support, unevenly developed digital infrastructures, or lack of time to play. In unison, these aspects indicate that the environment and preparedness affect AI adoption as much as attitude.

Table 4. Key Barriers to AI Adoption in ESP Teaching

Barrier	Number of Respondents Reporting It	Percentage
Lack of training	82	68.3%
Concern about inaccurate AI output	76	63.3%
Limited institutional support	61	50.8%
Poor digital infrastructure	50	41.7%
Time needed to learn AI tools	58	48.3%
Fear of overdependence on AI	46	38.3%

A useful way to express the relationship between AI adoption and barriers is through a simple adoption index:

$$\text{AI Adoption Index} = \frac{\text{Positive Use Responses}}{\text{Total Responses}} \times 100$$

This index helps represent how far teachers have progressed from awareness to actual use. The findings suggest that teachers with prior digital experience and access to training score higher on this index, while those without support remain hesitant. Another important metric is barrier frequency, which can be represented as:

$$\text{Barrier Frequency \%} = \frac{\text{Number of Respondents Reporting a Barrier}}{\text{Total Respondents}} \times 100$$

This helps identify which obstacles are most widespread. In this study, the quantitative pattern makes it clear that AI usage is promising but still uneven, and effective adoption depends on training, trust, and institutional readiness.

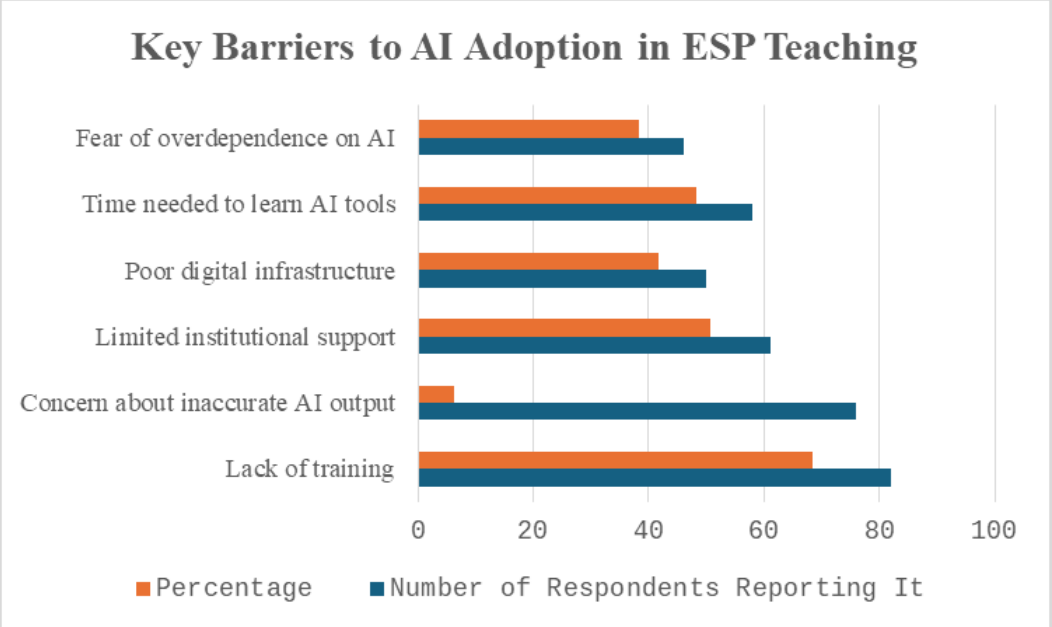

Figure2. Key Barriers to AI Adoption in ESP Teaching

5. Discussion

This section analyses the findings concerning the study aim, which is to investigate how collaborative AI can assist ESP teachers in transcending subject knowledge barriers. Based on the results, AI works best when it aids teachers in designing, explaining, and modifying specialized content, rather than replacing them in that role. It is important because ESP teaching requires not only technical accuracy but also pedagogical judgement, classroom sensitivity and the ability to connect content with learner needs. This means that AI must be viewed as a collaborator which enhances teacher capacity, enhances lesson quality and alleviates the stress

of teaching content with which they are not familiar.

5.1 Strategies for Collaborative AI in ESP

Starting with AI as a lesson preparation partner is practical collaborative AI strategy in ESP. Teachers can ask AI to generate vocabulary lists, case studies, and dialogue examples, reading passages or comprehension questions relevant to their classroom context. They can then adapt it to suit their students' level and context. Teachers get a jump start on the content development process, saving time. In ESP contexts, where both reliability and relevance are important, this model enables teachers to go beyond general materials and move toward real professional communication tasks.

Another successful strategy is to harness AI for a gradual teaching process. AI can assist in identifying key content from unfamiliar subjects and exploring them first. The teacher can now be able to check, simplify and reshape the content. In the end, the teacher can present the material when he uses examples and discussion questions adapted to learners. This layered strategy allows the teacher to keep control while utilizing the speed and breadth of AI. It also encourages teachers to use AI critically rather than passed on, something especially important in ESP where subject precision is of direct effect. In this context, collaborative AI acts as a mean to enhance learning possibilities without reducing teacher power.

5.2 Overcoming Barriers: Training and Ethical Considerations

According to the results obtained by the studies, it can be inferred that training has been determined to be one of the vital conditions necessary for successful AI adoption in ESP. Many teachers may be interested in using AI, but without some direction, they may not know how to ask for or assess the output, or to adapt it for use in his or her classroom. Professional development should therefore incorporate opportunities for prompt design, content verification, and lesson adaptation. Training should also make teachers aware that AI is not a foolproof technology and that its suggestions must be examined before using them in class.

Ethics are equally important. Teachers need concrete principles for responsible use as AI tools can create incorrect, biased and over-simplified content. Educational institutions should ensure that students' privacy is not breached by AI inputs. Second, there cannot be an over-reliance on machine-generated material. Third, AI must not distort the knowledge of disciplines. Another ethical demand of AI usage is transparency, i.e. teachers need to know when and how to use these tools for content delivery or students. When institutions make the policies clear and provide some ethical guidelines, the trust level towards AI will rise. We need to put safeguards in place so that AI can help enhance education without harming honesty or trust.

5.3 Implications for Teacher Professional Development

The study strongly affects teacher professional development in ESP as well. Conventional professional development usually concentrates on ways to teach languages, but the evidence here suggests that teachers also need digital tool support for content knowledge gaps. Future training programs should consequently merge awareness of the subject, AI literacy, and pedagogical adaptation. This assistance aids teachers in becoming increasingly confident in teaching specialized topics while being capable of developing accurate and engaging lessons.

Instead of attending one-off workshops, teachers should belong to learning communities. When ESP teachers share prompts to compare outputs, classroom experiences and co-develop material for a given subject, they benefit. Such working environment should help teacher reflect on their practice and combat the isolation experienced by many teachers teaching out of field. With time, this will create a more sustainable system of teacher growth, allowing them to build technological competence and content flexibility. AI has been addressed in this way to make sure that it not only solves an immediate issue as well as contributes to the empowerment of teachers in the long run.

5.4 Limitations of the Study

Even though the study has its twists, it has a few limitations that must be accepted. To start with, teacher perception drives most of the

findings, meaning they relied on the subjective experience of teachers rather than direct measures of classroom performance or student achievement. While they are of value, they do not necessarily correspond with real-world learning impacts of AI. Longitudinal research may include classroom observation and/or student feedback for data collection.

Moreover, the limited sample size and institutional context limit generalizability. Should the majority of participants hail from similar educational backgrounds or geographical locations, the results would not necessarily reflect the greater diversity of ESP teaching contexts. For a third time, the research examines a particular moment in the development of AI instruments, and the rapidly changing technology means that results could change as systems become more accurate and widespread. At last, the research supposes that teachers have some sort of digital access which may not be valid in all institutions. In spite of the above-mentioned limitations, the paper undoubtedly provides a sound basis for the beneficial employment of collaborative AI in ESP pedagogy.

6. Conclusion

All in all, collaborative-AI can participate meaningfully in real-world ESP teaching to manage the subject knowledge barriers faced by teachers that limit the quality and confidence of their teaching. Many teachers have a sound skill in language teaching. But they may not have enough content knowledge in their specific area of specialisation. AI enables teachers to quickly find definitions, explanations, examples, and lesson ideas that can be modified for their own classroom. Thus, it helps bridge the gap. Nonetheless, the research also clarifies that AI cannot ever replace specialized judgment. Its value is in augmentation, not substitution. Teachers are important because they help contextualize, assess accuracy, help calibrate tone and help make sure learning is pedagogically legitimate and ethically ok.

According to the findings, a teaching model that is driven by AI in partnership with a teacher. With this model of AI, the content preparation burden goes down, while teachers maintain control over classroom objectives, student engagement, and discipline relevance. Working together in this way can improve lesson quality, save preparation time, and increase teacher confidence, especially in ESP settings where the professional validity is important. The study simultaneously emphasizes the necessity of training, institutional backing, and verification of AI-generated content. AI systems are more likely to confuse than clarify without these safeguards.

In summary, the study provides a better analysis of the use of technology and how it strengthens language education, if used carefully. It also highlights a future where human-AI collaboration will make ESP instruction more flexible, responsive and inclusive. Collaborative AI won't undermine the teacher, but rather strengthen their role by providing educators with what they need to teach tailored content.

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