Exploring GAI integration in English language teaching: Insights from the TPACK model

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ABSTRACT: Generative Artificial Intelligence (GAI) tools have had a major impact on English Language Teaching (ELT). Thus, there is a dire need to understand how teachers use and integrate GAI in different contexts and educational settings. The Technological Pedagogical Content Knowledge (TPACK) model has been widely used to frame teachers' integration of this technology. The current study aimed to describe the knowledge, integration and use of GAI tools from a sample of English teachers from different educational levels in Colombia, a context less frequently studied in this emerging area of knowledge. A quantitative approach was adopted, using a non-experimental, cross-sectional design. A questionnaire based on the TPACK framework was administered to 76 English teachers across three institutional contexts. Findings show greater teacher competence in the domains of technological knowledge and technological content knowledge, but greater challenges in integrating technological knowledge within the pedagogical domain, as well as significant contextual barriers. This result is consistent across educational settings, suggesting a lack of resources and clear policies in all of them. Yet, differing profiles of engagement with GAI were identified through cluster analysis. These profiles might be instrumental in designing professional development programmes and institutional policies.
Keywords: English Language Teaching, TPACK Model, Generative Artificial Intelligence, Educational Technology, Teacher Perceptions.

Exploración de la integración de la IAG en la enseñanza del inglés: perspectivas desde el modelo TPACK

RESUMEN: La Inteligencia Artificial Generativa (IAG) ha tenido un gran impacto en la enseñanza del inglés. Por tanto, existe la necesidad de comprender cómo los docentes la están usando e integrando en sus prácticas de aula. Asimismo, el modelo de Conocimiento Tecnológico Pedagógico y de Contenido (TPACK) se ha utilizado ampliamente para enmarcar la integración de esta tecnología por parte de los docentes. Este estudio, con enfoque cuantitativo y diseño no experimental transversal, buscó describir el conocimiento, la integración y el uso de la IAG en una muestra de docentes de diferentes niveles educativos en Colombia, un contexto poco explorado. Se administró un cuestionario basado en el marco TPACK a 76 docentes en tres escenarios educativos. Los hallazgos muestran una mayor competencia docente en los dominios del conocimiento tecnológico y del conocimiento de contenido, pero limitaciones para integrar el conocimiento tecnológico en el ámbito pedagógico, así como importantes barreras contextuales. Este resultado es consistente en todos los niveles educativos, lo que sugiere la

falta de recursos y políticas claras en todos ellos. Un análisis de conglomerados permitió identificar diferentes perfiles de participación en IAG. Estos perfiles podrían ser fundamentales para el diseño de programas de desarrollo profesional y políticas institucionales.
Palabras clave: Enseñanza del idioma inglés, Modelo TPACK, Inteligencia Artificial Generativa, Tecnología Educativa, Percepciones docentes.

1. Introduction

The emergence of Generative Artificial Intelligence (GAI) represents a major development in educational technologies. Applications such as ChatGPT, Bing, and Gemini, based on large language models, are reshaping interaction, production, and personalisation in teaching and learning. Beyond automating tasks, GAI is transforming how knowledge is accessed, constructed, and understood, prompting a redefinition of roles and strategies in education (UNESCO, 2023).

In English Language Teaching (ELT), GAI tools offer functionalities such as text generation, content summarisation, activity design, and performance assessment. These affordances can support curriculum development, encourage authentic language use, and provide adaptive feedback (Morales-Acosta et al., 2024; Wang et al., 2024). Furthermore, GAI tools can help trigger emotional engagement and goal orientation in language learning (Derakhshan, 2025) and can be used for multiple specific learning purposes, such as enhancing oral skills (Fathi et al., 2024) and developing empathy, as in the case of healthcare practitioners (Derakhshan et al., 2025), amongst many other uses. However, their integration also raises questions about how teachers understand, implement, and evaluate them in practice. Effective use requires not only technical skills but also pedagogical awareness and alignment with language learning objectives (Rodríguez et al., 2024; Zhu & Wang, 2025). Despite the infinite possibilities, scholars have made an important call for critical and informed uses of these technologies and not their mere adoption (Kohnke & Zou, 2025; Morales-Acosta et al, 2024; Warschauer & Xu, 2024). Therefore, beyond compilations of tools and what they can be used for, the field recognises a need for theoretically sound principles to frame the integration of GAI.

These proposals are already underway. Weng and Chiu (2023) conducted a systematic review of 83 research papers on designing GAI-supported language instruction in learning environments and identified the First Principles of Instruction (FPI) model as not only the most frequently used for guiding such designs, but also as the most adaptable and flexible for these purposes. The model contends that learning becomes effective when centred on problem-solving and conveys five task-based principles: real-world problem solving, previous knowledge activation, demonstration, application, and integration of new knowledge in the learner's world (Weng and Chiu, 2023).

Precisely, teachers play a crucial role in integrating the GAI (Hernández & López, 2023). Rather than passive adopters, they act as mediators and ethical decision-makers. Their beliefs, knowledge, and institutional conditions significantly influence how GAI is adopted in classrooms (Aguilar & Salas, 2025). Understanding this role is key to fostering responsible and context-sensitive integration of AI in language education. In this sense, UNESCO proposed a framework of AI competencies for teachers of different areas of education (UNESCO, 2024). The Framework is made up of principles, dimensions and progression levels. While a detailed description of this framework is beyond the scope of the current study, its dimen-

sions point to the need to rethink the role of teachers and place teachers and students at the core of technology-aided pedagogy, along with strong ethical education. In short, while the tools are important, students and teachers and their constructions of these tools are central.

Accordingly, recent studies have explored teachers' perceptions and use of GAI tools in ELT. Diverse perspectives are evident, ranging from pedagogical enthusiasm to the exclusion of such technologies from the classroom (Derakhshan & Ghiasvand, 2024). Teachers commonly recognise GAI as a useful aid for lesson planning and materials development, as well as a means of optimising the time spent creating learning activities (An et al., 2023; Galán-Rodríguez et al., 2025; Zimotti et al., 2024). However, concerns have also been raised regarding ethical implications, academic dishonesty (Benek, 2025), and the potential decline in creativity, research skills, and critical thinking (Junguito & Chenoll, 2024). Additional concerns include students' over-reliance on these tools (Kalra, 2024) and the possible displacement of the teacher's role (Zimotti et al., 2024), among others.

Research has further highlighted disparities in the development of teachers' digital competences (Moorhouse, 2024; Moorhouse et al., 2024) and the influence of contextual factors on teachers' motivation to integrate GAI into their pedagogical practice (Collie et al., 2024). Consequently, there is a strong call for systematic and continuous professional development programmes that support teachers in engaging critically and reflectively with GAI (Kohnke & Zou, 2025; Rahimi & Sevilla, 2024). Studies focusing on changing teachers' perceptions and practices regarding GAI have reported positive effects on their knowledge, confidence, perceived usefulness, and intention to use such tools in the classroom (Kerr, 2024; Yeh, 2024).

The Technological Pedagogical Content Knowledge (TPACK) framework, originally developed by Mishra and Koehler (2006), has served for nearly two decades as a valuable model for analysing how teachers integrate technology in ways that align with their disciplinary and instructional goals. This framework emphasises the dynamic interplay between three fundamental domains of teacher knowledge: content (C), pedagogy (P), and technology (T). These domains are often examined in dyads—pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK)—each representing essential knowledge for organising, communicating, and enhancing subject matter through effective use of technology. Collectively, these components form the integrated construct of TPACK, which is "central to teacher's work with technology" and demands "a thoughtful interweaving of all three key sources of knowledge" (Mishra & Koehler, 2006, p. 1029). Scholars have expanded the model to include Contextual Knowledge (XK), recognising the influence of broader social, cultural, institutional, and technological systems on what teachers can or cannot do (Mishra & Warr, 2020; Warr et al., 2020).

More recently, the framework has evolved to incorporate contextual considerations and emerging technologies such as Generative Artificial Intelligence (GAI). As Mishra et al. (2023) argue, the advent of GAI calls for a shift from a utilitarian view of technology towards a more relational and ethical engagement with it. This shift entails navigating the issues of accessibility, algorithmic bias, data ethics, and the need to foster creativity and critical thinking among educators and learners.

As a result, there is growing academic interest in aligning the TPACK framework with the affordances and challenges of GAI (Celik, 2023; Chan & Tang, 2024; Luaran et al., 2024; Nu et al., 2024; Shoukat et al., 2024). However, despite this momentum, some significant gaps remain. Most studies have been conducted in Asian, European, and North American

contexts (Paidicán & Arredondo, 2024; Zhu & Wang, 2025), leaving a dearth of empirical evidence from Latin America, where differing economic, social, and political realities may shape technological integration in distinct ways. Additionally, existing research tends to focus on higher education, with few comparative studies across educational levels. Moreover, although there is a growing body of theoretical work on GAI within the TPACK, there is a pressing need for empirical studies and validated instruments suited to local contexts, especially in Spanish-speaking regions.

The present study seeks to address these gaps and describe Technological Pedagogical Content Knowledge (TPACK) on GAI-based instruction among English language teachers (ELT) from different educational levels in Colombia. By providing empirical data from an underexplored context, this study contributes to the emerging field of AI in education and offers practical guidance for teacher training, policy development, and curriculum design. Accordingly, this study was guided by the following research questions:

1. What is the self-reported level of knowledge and use of GAI tools among English language teachers in Colombia?
2. How do sociodemographic variables such as age, teaching experience, gender, academic degree, and institutional context relate to teachers' GAI-TPACK levels?
3. What teacher profiles can be identified based on patterns of engagement with GAI tools?

2. Method

2.1. Research Design

This study employed a quantitative, non-experimental, cross-sectional design to explore English language teachers' knowledge and use of GAI tools in diverse educational contexts. A non-probability convenience sampling method was used to recruit participants. Invitations were extended to English teachers across three groups: (1) all 53 working at a public university; (2) all 50 affiliated with the university's language outreach centre; and (3) a group of 109 from public secondary schools. The overall response rate was approximately 36%, considering an initial outreach to 212 teachers. While all participating teachers work in urban or peri-urban settings, rural teachers were not represented in the sample.

2.2. Instrument

Data were collected through a structured questionnaire specifically designed to assess teachers' perceptions and self-reported practices related to GAI tools in the context of ELT. The instrument was developed based on the TPACK framework as adapted by Chan & Tang (2024), integrating concepts from GAI-based technology use and language pedagogy.

The survey included 25 Likert-scale items, each rated on a 5-point scale ranging from 1 (Highly Unlikely) to 5 (Highly Likely). These items were grouped into five thematic sections:

- Part 1: Technological Knowledge (TK). Assessed participants' familiarity with the basic functionalities of GAI-based tools and their ability to troubleshoot technical issues.

- Part 2: Technological Pedagogical Knowledge (TPK). Focused on the extent to which GAI tools are integrated into daily teaching practices to improve workflow and classroom management.
- Part 3: Technological Content Knowledge (TCK). Explored how teachers use GAI to update or expand their English teaching knowledge and content expertise.
- Part 4: Technological Pedagogical Content Knowledge (TPACK). Measured the ability to align GAI tools with specific pedagogical strategies used in English language instruction.
- Part 5: Contextual Knowledge (XK). Investigated institutional readiness and the availability of support or infrastructure to incorporate GAI into classroom practices. While not directly part of the original TPACK framework, this section provides critical insight into environmental conditions that influence teachers' capacity to implement GAI tools effectively.

In addition to the Likert-scale items, the questionnaire collected sociodemographic information such as age, gender, years of professional experience, highest academic degree obtained, and current teaching context.

2.3. Validity and Reliability

To ensure content validity, the survey was evaluated by a panel of six expert reviewers with experience in English language teaching and educational technologies. All reviewers held at least a master's degree and had a minimum of five years' teaching experience at the university level. The expert validation process considered five criteria: relevance of the items, internal coherence, organisation of the survey, clarity of the questions, and appropriate length. The overall expert rating for the instrument was 4.7 out of 5, and the feedback provided was incorporated into the final version of the instrument.

The internal consistency of the Likert-scale items was assessed using Cronbach's alpha, which yielded a reliability coefficient of 0.96, indicating a high degree of inter-item correlation and strong reliability of the scale in measuring teachers' knowledge and use of GAI tools.

2.4. Data Collection and Analysis

The questionnaire was administered online via Google Forms. Academic coordinators in each of the three institutional contexts assisted in distributing the survey link to eligible participants. Data collection was conducted over a defined period and adhered to ethical standards for educational research. Participation was voluntary and anonymous, and informed consent was obtained from all respondents. Participants were explicitly informed about the purpose of the study, that their responses would be kept confidential, and that they had the right to withdraw at any time without consequence. No personally identifiable information was gathered, and all data were stored securely.

Following data collection, descriptive statistics were used to summarise participant characteristics and response trends. Correlation analyses were performed to explore the associations between Likert-scale scores and sociodemographic variables. Additionally, cluster

analysis was carried out to identify distinct groups of teachers based on their responses to the 25 Likert-scale items. Both hierarchical and non-hierarchical (k-means) methods were employed to determine the optimal number of clusters and describe the emerging profiles.

3. Results

3.1. Participants' Demographic Profile

As stated above, 76 English teachers voluntarily completed the survey. The respondents' average age is 39.3, with a mode of 38. The youngest participant was 21, while the oldest was 54. Besides, 44.7% of participants identified themselves as female and 52.6% identified themselves as males, while only 1 chose the option "Non-binary" and one chose "other". 95% of the teachers reported having a Bachelor's degree in foreign language teaching, and only 5% had degrees different from ELT, such as Business management, engineering, or literature. Regarding their graduate education, 49% of participants reported not having a graduate degree, 50% reported having a Master of Science in a field associated with language teaching, and only one participant reported having a PhD degree. As for their teaching experience, most respondents (59%) reported 10 years or more of experience teaching English, 24% reported experience in the range of 6 to 10 years, 16% were in the range of 1 to 5 years, and only one respondent had less than 12 months of experience. Finally, in terms of the contexts in which participants teach, most respondents teach English as a foreign language at public schools at the secondary education level (39%), followed by a third of the participants who teach English at college level in courses of English for Academic Purposes (33%) and the last group of teachers who teach English at the outreach language programme (28%). This information is visually presented in Figure 1.

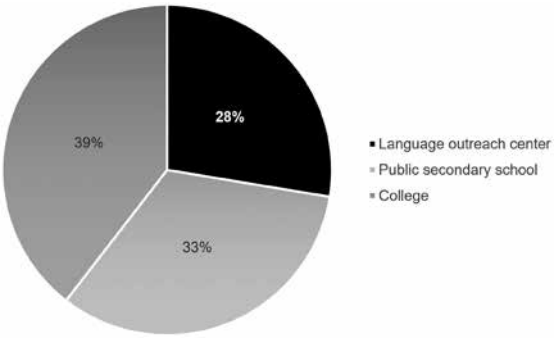

Figure 1. *Distribution of participants according to the context in which they teach English*

3.2. General Trends in Teachers' Knowledge and Use of GAI Tools

Responses to the questionnaire draw some clear trends in teachers' knowledge, understanding, and use of GAI tools and the institutional support they perceive in their practice. Table 1 shows that teachers scored the highest in TPK, followed by TK, and TCK as the

second and third highest components of the questionnaire. This suggests that teachers at all three levels are likely to use GAI tools for everyday teaching, that they are relatively familiar with these tools, and that they are also prone to use them to reinforce or strengthen their own knowledge of the English language and preparation of the content of what they teach. Yet, it is important to notice that, although these are the components with the highest means, none reached values above 4, indicating a moderate level of knowledge rather than solid knowledge.

Table 1. *Questionnaire results by components*

Components	M	SD
Part 1 Technological Knowledge (TK)	3.31	1.18
Part 2 Technological Pedagogical Knowledge (TPK)	3.42	1.15
Part 3 Technological Content Knowledge (TCK)	3.26	1.22
Part 4 Technological Pedagogical Content Knowledge (TPACK)	2.92	1.28
Part 5 Contextual Knowledge (XK)	2.04	1.10

On the other hand, the two low-scoring components were the integrative dimension (TPACK) and the XK, respectively. While teachers use different GAI tools in their teaching, their knowledge is more limited when it comes to specific teaching strategies such as assessment, personalising instruction, and promoting learners' autonomy. Finally, most teachers feel the institutional support (training, infrastructure, and policies) to integrate GAI tools in their teaching is scarce, with a mean of 2.04. While the means of the different components of the questionnaire showed moderate and low scores, standard deviations were relatively high, indicating heterogeneous levels of likelihood in participants' responses and divided views on what they know of and what they use GAI tools for.

To better understand these results, Figure 2 below offers a more fine-grained view of participants' responses. At a glance, frequency responses to individual items confirm what the analysis by components had already indicated. Most respondents feel that they know about GAI tools and some basic tasks that can be completed with these tools. Unsurprisingly, they felt less confident when it came to technical problems, an area in which the majority felt uncertain or incapable of solving technical issues associated with the use of GAI tools. It is clear that most teachers are open to using GAI tools to teach since most teachers recognise the pedagogical contribution of GAI tools to ELT. They also reported frequently using GAI tools for lesson planning, supplementing their lessons with additional material, and selecting and adapting materials for their lessons. While the trend is similar in the rest of the items, the percentage of teachers who felt uncertain about their use of GAI tools to motivate students or to optimise their teaching time equals or surpasses a quarter of respondents (between 23% and 27%). In addition, many teachers use GAI tools to reinforce and consolidate their own knowledge of English and the content of their lessons. Nonetheless, it is worth highlighting that the percentage of uncertain teachers was again close to or superior to a quarter of the respondents (items 14 and 15).

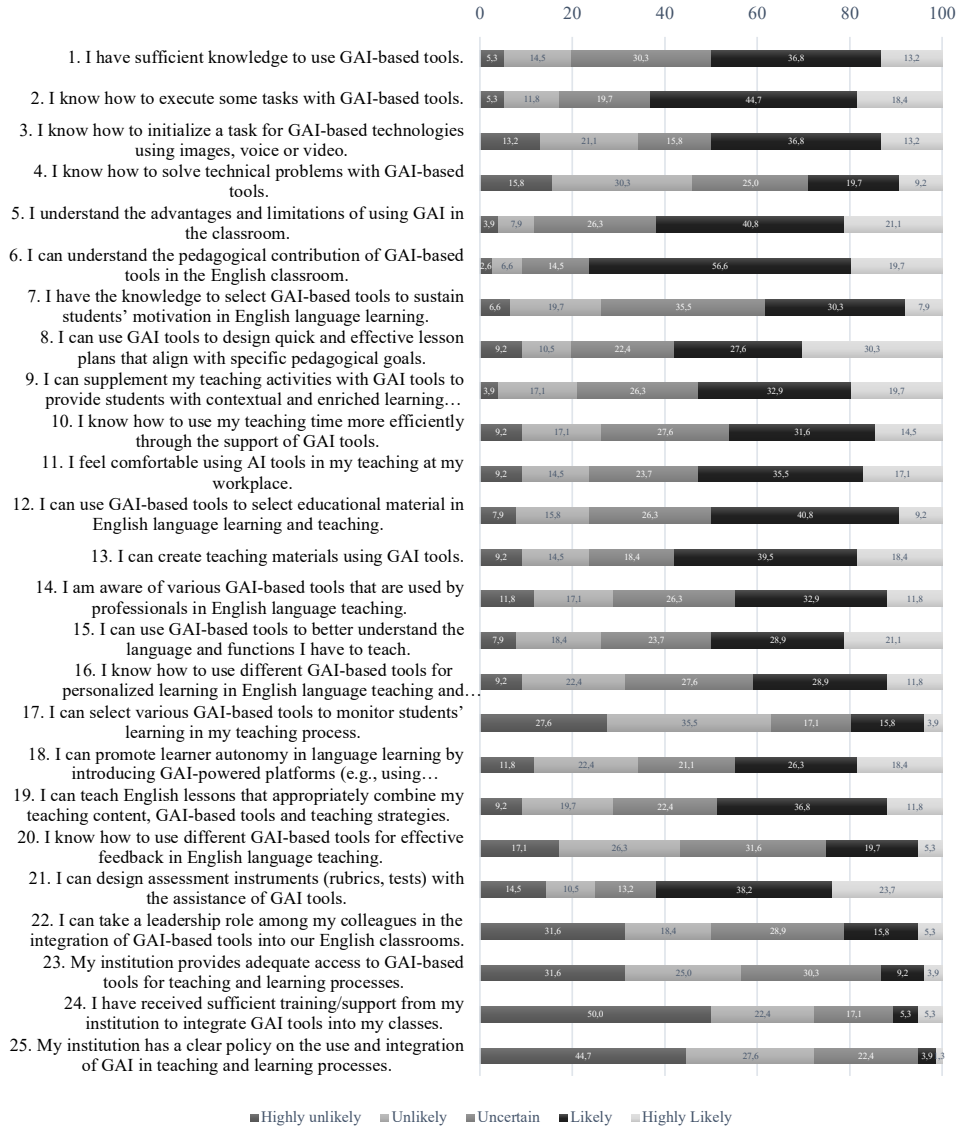

Figure 2. *Results of the questionnaire by item*

When it comes to personalising learning, promoting learners' autonomy, monitoring and assessing students, and providing feedback, that is, the integrative dimension of the different types of knowledge, teachers' confidence and propensity to use GAI tools seem to be more limited. It can be seen, for instance, that while almost 60% of respondents use GAI tools to design assessment instruments such as quizzes and scoring rubrics, fewer teachers

reported using GAI tools for monitoring students' learning and providing feedback. This might represent a lack of knowledge of the tools that perform such tasks or, on the contrary, evidence that teachers feel these tasks are to be carried out by a human teacher and not by the machine. More in-depth and qualitative studies could further explore these plausible explanations. Finally, responses to items 23 through 25 show that teachers feel that there is little or no support from their institutions to implement or use GAI tools. This lack of support is consistent (over 60% of the teachers) in terms of technological access, technical support, training, and clear policies.

3.3. Correlations between Sociodemographic Variables and Total Score

This section presents the results of inferential analyses conducted to examine the relationship between the overall GAI-TPACK score (computed as the mean of the 25 Likert-scale items) and selected sociodemographic variables: age, years of teaching experience, gender, highest academic degree, and current workplace.

Pearson's correlation coefficient was used to assess the relationship between the total score and participants' age, as both are continuous variables. The analysis revealed a statistically significant negative correlation between age and GAI-TPACK scores (r = -0.279, p = .015) (Table 2). This finding suggests that older participants tend to report lower levels of perceived knowledge and integration of GAI tools. According to contemporary benchmarks for interpreting effect sizes in educational research (Cohen, 1992; Fritz et al., 2012), this correlation represents a moderate effect.

Table 2. *Correlations Age-Total Score*

Variables	Pearson's r	Sig. (2-tailed)	N
Age-Total Score	-.279*	.015	76

*. Correlation is significant at the 0.05 level (2-tailed).

Given that years of teaching experience were collected as an ordinal variable, Spearman's rank-order correlation was used. A statistically significant negative correlation was also observed (ρ = -.310, p = -006) (Table 3), which also corresponds to a moderate effect size. This indicates that teachers with more years of experience tend to report lower scores on the GAI-TPACK scale, possibly reflecting generational differences in technology adoption or familiarity with AI tools.

Table 3. *Correlations Experience-Total Score*

VARIABLES	SPEARMAN'S P	SIG. (2-TAILED)	N
Experience-Total Score	-.310*	.006	76

*. Correlation is significant at the 0.05 level (2-tailed).

To explore whether there were differences in the overall GAI-TPACK scores across categorical sociodemographic groups, one-way ANOVA tests were conducted for gender, highest academic degree, and current workplace. The results showed no statistically signif-

icant differences between groups in any of these variables, suggesting that self-perceived knowledge and the use of generative AI tools were not associated with these demographic factors in this sample. As expected, the associated effect sizes were negligible, indicating limited practical differentiation across the groups.

3.4. Cluster Profiles of GAI Integration

3.4.1. Principal Component Analysis (PCA)

To reduce the dimensionality of the 25 Likert-scale items and identify latent constructs underlying teachers' knowledge and use of GAI, a Principal Component Analysis (PCA) with Varimax rotation was conducted. Prior to the analysis, the suitability of the data was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. The KMO value was 0.94, indicating strong sampling adequacy, while Bartlett's test was statistically significant ($p < .001$), confirming sufficient inter-item correlations for factor analysis.

The PCA yielded three components with eigenvalues greater than 1, which together explained 70.04% of the total variance (Table 4). This high proportion of explained variance suggests a robust latent structure underlying teachers' responses, consistent with criteria for strong factor solutions in educational research. The first component dominates the solution, indicating a strong unidimensional structure, while the second and third components capture more specific subdimensions related to the contextual and integration of GAI in teaching.

Table 4. *Total Variance Explained*

Component	Initial Eigenvalue	% of Variance	Cumulative %
1	12.846	58.390	58.390
2	1.486	6.754	65.144
3	1.076	4.893	70.037

The components were interpreted as follows:

- Component 1 accounted for 58.39% of the variance and represented a general factor combining both pedagogical and technical aspects of GAI use. It included high loadings across all four survey dimensions, particularly items such as *"I can supplement my teaching activities with GAI tools"*, *"I can create teaching materials using GAI tools"*, and *"I can teach English lessons that appropriately combine content, tools, and strategies"* (all with loadings > .800). This component appears to reflect a broad and integrated understanding of GAI-supported teaching practices.
- Component 2, which explained 6.75% of the variance, grouped items related to institutional support and leadership. Although fewer items loaded exclusively on this component, relevant examples include *"I can take a leadership role among my colleagues in the integration of GAI tools"* (.695) and *"I feel comfortable using AI tools in my teaching at my workplace"* (.486). This component seems to capture contextual and professional confidence in institutional GAI integration.

- Component 3, contributing 4.89% to the variance, reflected aspects of attitudinal awareness and pedagogical reflection. While this component had fewer distinct loadings, it included moderate contributions from items such as *"I can understand the pedagogical contribution of GAI-based tools"* (.428) and *"I feel comfortable using AI tools…"* (.486). This factor may represent a dimension of critical engagement and reflective attitudes toward the educational use of GAI.

The resulting components were used to generate regression-based factor scores, which served as input for the subsequent cluster analysis aimed at identifying teacher profiles based on their responses to the GAI-TPACK items. The full rotated component matrix revealed that each item loaded primarily on one of the three components, supporting the internal consistency and conceptual coherence of the factor structure.

3.4.2. Cluster Analysis

To identify distinct profiles of English teachers based on their engagement with GAI tools, a cluster analysis was conducted using the regression factor scores derived from the PCA. First, the optimal number of clusters was determined using the elbow method, which involved plotting the within-cluster sum of squares (WCSS) against different numbers of clusters. The analysis revealed a visible inflection point in the three clusters. This decision was further supported by a hierarchical cluster analysis (Ward's method, squared Euclidean distance), where the dendrogram also suggested a three-group structure.

Subsequently, a k-means clustering algorithm was applied to assign participants to the clusters based on their standardised factor scores. The clustering process revealed three distinct groups of teachers, each characterised by their patterns of engagement with GAI tools across the three components: pedagogical-technical use, institutional support and leadership, and attitudinal factors (see Table 5).

Table 5. *Final Cluster Centers (Standardised Regression Factor Scores)*

Component	Cluster		
	1	2	3
Component 1	-.78596	1.01021	.04136
Component 2	-.72007	-.48048	.92837
Component 3	.09022	-.69343	.36098

Note: Negative values indicate below-average engagement or perceptions in that dimension, while positive values indicate above-average levels.

Table 6 shows the number of participants in each cluster, confirming a relatively balanced distribution across groups. This suggests diversity in teacher profiles without one group overwhelmingly dominating the sample.

Table 6. *Number of Cases in each Cluster*

Cluster	1	26
	2	19
	3	31
Valid		76
Missing		0

Table 7 reports the Euclidean distances between cluster centers. Larger distances indicate greater dissimilarity between clusters. For instance, Clusters 2 and 3 are the most distinct from each other in terms of factor profiles, while Clusters 1 and 3 are more similar. The observed Euclidean distances between cluster centers (ranging from 1.864 to 2.009) suggest meaningful practical differentiation between groups. These values reflect well-separated profiles of GAI engagement and support the interpretative validity of the three-cluster solution.

Table 7. *Distances Between Final Cluster Centers*

Cluster	1	2	3
1		1.974	1.864
2	1.974		2.009
3	1.864	2.009	

Based on these findings, a possible interpretation of the cluster groupings is as follows:

- Cluster 1 (n = 26): Teachers in this group exhibited low scores in both pedagogical-technical use and institutional support but showed neutral to slightly positive attitudes toward GAI tools. Based on the factor scores, this group appears to represent teachers who engage less actively with GAI tools, possibly because of limited institutional support or personal reservations about technology. These teachers might be categorised as low-engagement or cautious adopters.
- Cluster 2 (n = 19): This group displayed high scores in pedagogical-technical engagement, but lower scores in attitudinal and institutional support. These teachers seem to be capable of using GAI tools for instructional purposes but face challenges in terms of institutional backing and perhaps hold more neutral or ambivalent attitudes toward their broader integration. This cluster is likely composed of individual innovators working in environments where support for GAI adoption is minimal, and they may operate with greater autonomy.
- Cluster 3 (n = 31): Teachers in this group showed moderate to high scores across all three components, with particularly strong scores in attitudes toward GAI and institutional alignment. This suggests that these teachers are not only capable of integrating GAI tools into their teaching but also enjoy a supportive environment that fosters innovation. These teachers can be characterised as well-rounded adopters—both proactive and skilled in using GAI to enhance teaching practices.

It is important to note that these interpretations are based on the observed patterns in the data, derived from the factor scores produced by the PCA. While the clusters reflect clear trends in the teachers' self-reported use of GAI tools, they represent general patterns rather than rigid classifications. The results should therefore be understood as indicative of potential profiles of GAI integration, rather than definitive labels.

4. Discussion

Results suggest that this sample of Colombian English teachers in three different educational contexts has moderate knowledge when it comes to the use of GAI tools in their teaching. The strongest components are TK and TPK, as teachers report familiarity with GAI tools for language teaching and their potential application. Compared to previous studies, the results are consistent in that teachers seem to achieve higher scores on the TK and TPK components (Chang & Tang, 2024; Luaran et al., 2024; Nu et al., 2024). As found in previous studies (Aguilar & Salas, 2025; Chang & Tang, 2024; Kohnke & Zu, 2025), the use of GAI tools is strong in everyday teaching tasks associated with lesson management and complementary materials, while more complex teaching strategies associated with personalisation, feedback, and monitoring score moderate mean scores. Aguilar and Salas' (2025) survey of Colombian school teachers' perceptions of artificial intelligence reported similar results. While teachers have moderate levels of the different types of knowledge required for the implementation of new technologies, their integration of these tools into pedagogical practices remains limited. This finding points to the need for support in the integrative dimension of the TPACK framework—its core element—which requires a dynamic interplay between technological, pedagogical, and content knowledge (Mishra & Koehler, 2006). As Mishra and Warr (2020) highlight, such integration is highly dependent on contextual knowledge (XK).

The lowest scoring components refer precisely to contextual factors and institutional support. Respondents perceive that their institutions do not fully offer the technical infrastructure, training, and professional development opportunities needed for GAI integration, nor do they provide clear policies regarding its use. Previous studies on English language teaching in Colombian public schools already indicated that the availability of resources and infrastructure is limited and outdated (Miranda, 2021). The results of this study confirm that this situation persists and, significantly, is also present in higher education. These findings reinforce the call for comprehensive strategies that transcend mere access to tools and take into account interactions with meso- and macro-level contextual dimensions

In this regard, the UNESCO AI Competency Framework for Educators (2024) becomes especially relevant. It emphasises the importance of a human-centred approach to AI, the development of an AI pedagogy, and the need for continuous professional development. Beyond knowing how to use GAI tools, teachers need structured support to understand how to integrate these technologies ethically and critically—and how to teach students to do the same (UNESCO, 2023, 2024).

In terms of the relationships between personal factors and the results in the different levels of knowledge from teachers, there were no statistically significant differences among teachers based on the context in which they teach. Teachers at secondary education, higher education, or at the outreach programme display similar levels of technical, pedagogical

and content knowledge and even similar perceptions of the institutional conditions. On the other hand, cluster analysis allowed the identification of three different profiles regarding their interactions with GAI. From the five components of the instrument, TK, TPK, and XK seem to define these profiles in which teachers can be grouped. Further studies could confirm these profiles with larger samples of participants. The correct identification of teachers could allow for policy making both in terms of use and professional development programmes tailored to the needs and experiences of teachers.

A finding worth highlighting is the significant negative moderate correlation between both age and years of teaching experience with overall scores in the GAI-TPACK instrument. This suggests that older and more experienced teachers tend to report lower levels compared to younger teachers. These results support widely held assumptions about generational differences in digital literacy and openness to innovation. Younger teachers may be more willing to experiment with emerging technologies and incorporate them into their instructional practices. This finding aligns with the argument that professional development programmes should be differentiated and responsive to the needs of teachers with diverse levels of experience and digital confidence (Kohnke & Zou, 2025).

The overarching theme that was found is the importance of contextual factors as has been reported in previous studies (An et al., 2023; Collie et al., 2024; Rahimi & Sevilla, 2024). Institutional conditions—including access to technology, training opportunities, and clear guidelines—play a key role in shaping teachers' attitudes and dispositions towards GAI. Although still an emerging field, GAI tools are becoming increasingly present in educational settings, and teachers require the tools, knowledge, and pedagogical vision to integrate them meaningfully and ethically. Policies aimed at restricting or forbidding the use of GAI tools are likely to be ineffective since both teachers and learners are already using these tools frequently. Yet, both teachers and students would benefit from clear institutional guidelines on ethical uses and purposive integration of AI in general in assignments, assessment and content generation. Teachers can be included in the policymaking process through field research that provides more careful description of practices and in-depth interviews on what is and should be GAI appropriate use.

The current study contributes to understanding how teachers of English are using and integrating GAI. The contribution also lies in the fact that the population comes from one of the least studied educational and geographical settings (Paidicán & Arredondo, 2024). Nonetheless, the results are to be interpreted with caution due to the sample size and non-probabilistic sampling method. Further studies could overcome these limitations and provide more robust findings. Even so, these results do offer insights into the need for clearer policies, infrastructure upgrades, and context-sensitive professional development programmes.

These results also highlight the need for further research. First, teacher affiliation to different educational levels yielded no important differences. However, most participants in the study work in urban and peri-urban contexts. Thus, teachers in rural areas remain largely unstudied, and there is little data on their access, knowledge and use of GAI. Moreover, other variables such as digital literacy and specific prior training, and familiarity with technology were not considered in our design. These could be more instrumental than academic formal degrees and are variables worth examining in future studies. In addition, combining quantitative and qualitative approaches would enrich the contributions from the current study by

providing a more fine-grained description of teachers' attitudes, knowledge and actual uses of GAI. Finally, GAI-aided or GAI-powered teacher professional development seems to be a new emerging area of research that could be supported by participatory action research and design thinking perspectives.

To be effective, teacher training must be tailored to educators' current levels of knowledge, attitudes, and professional trajectories. For instance, younger and less experienced teachers may benefit from opportunities to deepen their pedagogical use of GAI tools, whereas more experienced teachers might need initial confidence-building and orientation. Regardless of the teaching context, all teachers need sustained support to move beyond superficial or instrumental uses of GAI. This is essential for these technologies to reach their full potential in the English as a Foreign Language (EFL) classroom and to contribute meaningfully to language learning and teaching.

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