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IDLE PRACTICES OF ESP STUDENTS: ENHANCING PROFESSIONAL AND INFORMAL COMMUNICATION IN XR-SUPPORTED CONTEXTS

Abstract

This study examines how informal digital learning of English (IDLE) is perceived as useful for developing English for specific purposes (ESP) competencies, particularly in professional, academic and informal communication within extended reality (XR) supported contexts. Data were collected from 143 undergraduate students on their engagement in digital English practices and their perceived usefulness for ESP learning. Exploratory factor analysis identified four dimensions of perceived usefulness: Social and interactive communication, Functional and informational literacy, Technology-assisted and structured learning and Media and academic content consumption. These were used as predictors in regression models targeting three outcomes: (1) Immersive academic and professional language use, (2) Interactive comprehension and speaking skills, and (3) Casual and written communication in XR-supported contexts. Results show that Technology-assisted and structured learning is the strongest predictor of Immersive academic and professional language use, while Social and interactive communication best predicts Casual and written XR-supported communication. The findings suggest that different IDLE practices support distinct ESP competencies. Structured practices align with academic and professional discourse, whereas informal interaction fosters communicative fluency for collaborative XR-supported environments. The study highlights the need to integrate both practice types in ESP pedagogy.

Key words

informal digital learning of English (IDLE), extended reality (XR), English for specific purposes (ESP), university students.

1. INTRODUCTION

Technological innovations are radically reshaping our daily activities, impacting every segment of our lives from education and professional engagement to leisure activities and entertainment. This particularly holds true for emerging extended reality (XR) technologies that are dramatically transforming the way we experience and interact with our surroundings (Dias et al., 2025). By creating highly immersive and engaging experiences, these cutting-edge technologies provide a physical representation of a virtual environment and thus allow real and virtual worlds to coexist and interact (Jerly & Sathya, 2024). In so doing, these technologies eliminate boundaries between the physical and digital realms.

Just as emerging technologies dissolve the divide between the real world and the virtual one, so do they blur the lines between learning in formal and informal contexts. By creating entirely new communication systems, innovative technologies bear the potential to transform how knowledge is generated, curated, and disseminated (Romero-Luis et al., 2025). With English adopting the role of a lingua franca in these digitalized communication environments, contemporary English as a foreign language (EFL) learners are given plenty of opportunities to use and practice their target language in a wide range of extramural digital contexts. The phenomenon has attracted the attention of EFL scholars and given rise to a new field within EFL teaching and learning methodology referred to as Informal Digital Learning of English (IDLE) defined as "self-directed English activities in informal digital settings, motivated by personal interests and undertaken independently without being assessed by a teacher" (Lee & Lee, 2021, p. 359). Rezai and Goodarzi (2025) claim that IDLE can be treated as a dynamic substitute for the conventional classroom environment, which may lack stimulation for contemporary EFL learners. As such, IDLE has challenged current EFL pedagogical models and practices and opened a wide pool of ideas to be researched and explored. The present study is intended as a contribution in this regard by bringing IDLE to the field of English for specific purposes (ESP) through examining the IDLE practices of ESP students and analyzing their predictive role in developing competencies of English for professional, academic and informal communication in various XR-supported technology contexts.

XR technologies represent advanced media tools characterized by their immersive and interactive capabilities (Romero-Luis et al., 2025). They can be employed in various segments of our lives, such as education, healthcare, scientific research, and business. With XR technologies users immerse themselves and become engaged in more interactive and effective digital world experiences. XR technologies are changing the way we communicate, from social interactions to academic and professional communication. As for science communication, Romero-Luis et al. (2025) observe that XR tools have a great potential to foster scientific literacy and promote scientific inquiry. Their analysis of a selected corpus of papers and conference presentations over the last decade has shown that XR technologies

are used for communication, dissemination, education and training, and decision-making, thus pointing to the emerging significance of XR technologies for scientific communication in terms of presenting information and data, conveying complex scientific ideas, and gamifying learning environments (Romero-Luis et al., 2025). A significant impact of XR technologies has been observed in the context of business, and more specifically in fields such as product design, customer engagement and marketing, global connection, communication and the training of employees (Jerly & Sathya, 2024). Given that XR technologies bring radical shifts in various professional fields and impact professional communication and social interaction in general, there is a clear need to examine this evolving trend from an ESP perspective. Accordingly, this study aims to investigate how contemporary ESP students' digital practices involving XR technologies beyond the formal classroom contribute to the development of their English language competencies for professional, academic, and everyday communication, and what pedagogical implications these practices bring to the field of ESP.

2. LITERATURE REVIEW

As noted above, IDLE is referred to as an autonomous, self-directed English learning activity that occurs in digital settings outside of school, driven by personal interest and not assessed by teachers (Lee & Lee, 2019, 2021), such as watching YouTube videos, reading blogs or posts on social media, participating in online discussions, following podcasts, etc. Although it takes place outside the formal educational context, it can still be linked to it: for example, English language learners may watch tutorials to prepare themselves for a formal task. Addressing this conceptualization inconsistency and building on Benson's (2011) four-dimension framework of learning languages beyond the classroom, Lee (2019) distinguishes between two IDLE contexts: the extracurricular and the extramural IDLE. The former implies "self-directed, self-instructed, digital learning of English in semi-structured, out-of-class environments that are linked to formal education" (Lee, 2019, p. 115), while the latter refers to "self-directed, naturalistic, digital learning of English in unstructured, out-of-class environments, independent of a formal language program" (Lee, 2019 p. 116). As Zhang and Liu (2024) observe, most of IDLE studies have taken the latter stance and that context falls within the scope of the present study.

Depending on students' engagement, Lee and Drajati (2019) further divide IDLE into receptive and productive, the former including content-consumption practices and the latter being oriented towards content-production in English. A considerable body of research has focused on IDLE activities' outcomes and in certain number of the studies educational gains have been confirmed. From the linguistic side, therefore, educational gains have been reported in communicative competence enhancement, including speaking and productive vocabulary use (Lee, 2019; Lee & Dressman, 2018; Sundqvist, 2019). Lee (2019), for example, has found that IDLE diversity is significantly predictive of Korean university students'

speaking skill, vocabulary knowledge and standardized English language test scores. Academic achievement outcomes have also been reported in studies with quantitative and mixed-method designs where students who actively engage in IDLE showed higher performance in standardized Test of English for International Communication (TOEIC) (Lee & Dressman, 2018). Further, in their large-scale study with Swedish university admission test takers, Neagu et al. (2025) have detected a significant positive correlation between the subjects' extramural English activities and reading comprehension ability. Certain benefits have been reported in the affective domain as well. Lee and Lee (2021) show that IDLE engagement correlates with higher student motivation. A strong relationship between EFL students' motivation and self-confidence and the diversity of their IDLE activities has been reported by Lee (2019). Positive relationships have also been detected in EFL enjoyment (Lee, 2019), willingness to communicate (Lee & Drajati, 2019; Lee et al., 2024), and ideal L2 self (Liu et al., 2024), while some authors have reported reduced anxiety (Lee & Drajati, 2019; Lee et al., 2024). Rezai (2023) has pointed to IDLE's capacity to enhance learners' intercultural awareness and competence. Finally, one of the frequently reported educational benefits of IDLE practices is the enhancement of autonomous language learning and learner independence (Dincer, 2020; Kuru Gonen & Kızılay, 2023). Based on the information presented above, Chen (2022) highlights the potential of IDLE to create and develop lifelong learning skills due to a number of linguistic, affective, and cultural benefits that this practice can offer.

The extensive pool of empirical evidence regarding how IDLE practices impact EFL learners' language development has contributed to positioning IDLE as a new individual difference (ID) variable within the context of EFL teaching and learning (Sundqvist, 2024). The latest research has pointed to a complex interplay of IDLE and other ID variables such as ideal L2 self, L2 enjoyment and self-efficacy in the process of EFL development (Chen, 2022; Liu et al., 2024). Recognizing IDLE as a distinct ID factor, as Liu et al. (2025) observe, has marked a structural shift in modern EFL pedagogy from traditional in-classroom instruction toward self-directed, out-of-class learning. This structural change affects all fields of EFL, including ESP. However, a review of IDLE-related literature indicates that this phenomenon has largely remained neglected within the field. The identified research gap served as the initial motivation for conducting the present research. Additional reason for undertaking this study lies in the rapidly growing development and usage of XR technologies that are radically reshaping the way we gain, transfer and communicate knowledge in the 21st century.

3. METHODOLOGY

In order to examine how different dimensions of IDLE engagement relate to students' perceived ESP development in XR-supported environments, the study implemented a quantitative design structured around two research questions:

RQ1: How do different types of IDLE practices relate to students' perceptions of the usefulness of IDLE for developing specific ESP-related language skills?

RQ2: How do distinct clusters of students differ in their perceptions of the usefulness of these practices for ESP development in XR-supported contexts based on their engagement in IDLE practices?

XR-supported contexts in this study refer to digitally mediated environments in which communication is extended through immersive or interactive technologies (e.g., virtual or augmented reality). In this sense, the focus is not on the technologies themselves, but on the types of communicative demands these environments place on users, such as real-time interaction, multimodal input and active participation.

The research followed a survey-based paradigm, aiming to capture both predictive relationships and patterns of learner behavior. A cross-sectional design was employed, using self-report questionnaires to collect data on students' engagement in IDLE practices, their perceived usefulness of these practices for ESP learning and their language-related outcomes in XR-supported contexts.

3.1. Participants

The participant pool consisted of 143 undergraduates enrolled at the University of Novi Sad (see Table 1).

		M	F	Total
Faculty of Agriculture	N	6	3	9
	%	4.2%	2.1%	6.3%
Faculty of Sciences	N	34	38	72
	%	23.8%	26.6%	50.4%
Faculty of Technical Sciences	N	28	24	52
	%	19.6%	16.8%	36.4%
Faculty of Technology	N	2	8	10
	%	1.4%	5.6%	7.0%
Total	N	70	73	143
	%	49%	51%	100%

Table 1. Research participants

The gender distribution was nearly balanced, with 70 male (49.0%) and 73 female participants (51.0%). Participants represented all four years of study, with the average age of 20.43 years (SD = 2.01) ranging from 18 to 29. Their level of English ranged between A2 and B2 levels of the CEFR as determined by placement procedures conducted at their respective faculties at the beginning of the school year.

3.2. Instrument

The instrument consisted of two multi-item survey measures developed specifically for this study.[1] The items were based on Kuru Gonen and Kızılay (2023) and Jurkovič (2019) and were designed to capture students' engagement in IDLE practices (rated on a scale from 1 – 'I never do this' to 5 – 'I always do this') and their perceptions of the usefulness of these practices for developing ESP-related skills in XR-supported contexts (rated on a scale from 1 – 'Not useful at all' to 5 – 'Very useful'). Both scales underwent an exploratory factor analysis (EFA) to establish construct validity and ensure that the items reliably reflected underlying dimensions of informal learning and perceived usefulness.

Table 2 presents the results of the EFA conducted on the IDLE survey items. Sampling adequacy was confirmed with a Kaiser-Meyer-Olkin (KMO) value of .833, while Bartlett's Test of Sphericity was significant, $\chi^2(df = 1225) = 4829.779$, $p < .001$, indicating that the data were suitable for factor analysis. Four factors were extracted, jointly explaining 73.4% of the total variance.

Item (*How often do you use English when doing the following activities online?)*	Factor loading	Communality (h^2)	α
Factor 1: Social and interactive communication			
Talking with colleagues	0.78	0.65	
Texting with colleagues	0.74	0.62	
Talking with friends	0.81	0.69	
Texting with friends	0.77	0.66	
Reading posts/comments	0.70	0.59	.828
Factor 2: Functional and informational literacy			
Online dictionaries	0.76	0.64	
Translation apps (EN → native)	0.73	0.61	
Translation apps (native → EN)	0.71	0.60	
English learning apps	0.79	0.67	
Practice websites for English learning	0.75	0.63	.806

[1] The full version of the survey can be found in the Appendix.

Factor 3: Technology-assisted and structured learning			
Watching tutorials (study-related)	0.82	0.71	
Watching tutorials (for learning EN)	0.80	0.70	
Watching tutorials (skills/knowledge)	0.77	0.66	
Listening to lectures in English	0.74	0.62	
Reading texts outside field	0.72	0.60	.753
Factor 4: Media and academic content consumption			
Watching films/series (no subtitles)	0.81	0.68	
Listening to news in English	0.76	0.63	
Reading daily press in English	0.74	0.61	
Following podcasts in English	0.79	0.65	
Watching sports in English	0.71	0.58	.818

Table 2. Exploratory factor analysis of IDLE practices

Factor 1 (Social and interactive communication) includes 5 items reflecting both oral and written everyday interpersonal exchanges in English with peers and friends, as well as informal interaction through social media. Factor 2 (Functional and informational literacy), with 5 items, captures the use of English for practical purposes such as consulting online dictionaries, employing translation tools and engaging with language learning applications. Factor 3 (Technology-assisted and structured learning) groups 5 items related to more formalized or academic learning contexts, including watching tutorials, listening to lectures and reading texts in English for study or professional development. Factor 4 (Media and academic content consumption), with 5 items, comprises activities that involve exposure to authentic English media, such as films, news, podcasts and sports broadcasts. All items demonstrated satisfactory communalities and factor loadings exceeded conventional thresholds, indicating that the four-factor solution provides a reliable representation of the underlying constructs. Reliability analyses showed good internal consistency, with Cronbach's alpha values ranging from $\alpha = .753$ to $\alpha = .828$ across the four factors.

A second EFA exploring the perceived usefulness of online practices on different ESP learning segments in XR-supported contexts was conducted on the 13 items (see Table 3). The Kaiser-Meyer-Olkin (KMO) measure confirmed sampling adequacy (KMO = .862), and Bartlett's test of sphericity was significant ($\chi^2(105) = 1433.72$, $p < .001$), supporting the suitability of the dataset for factor analysis. Principal component analysis with Varimax rotation yielded a three-factor solution, explaining 66.64% of the total variance.

Item *(How beneficial is IDLE in improving the following ESP segments?)*	Factor loading	Communality (h^2)	α
Factor 1: Immersive academic and professional language use			
Communication related to study area content	0.82	0.73	
Learning specialized vocabulary	0.75	0.66	
Comprehension of specialized oral communication	0.76	0.73	
Reading comprehension of specialized topics	0.78	0.72	
Learning general vocabulary	0.41	0.49	
English grammar	0.49	0.49	.862
Factor 2: Interactive comprehension and speaking skills			
Comprehension of everyday oral communication	0.81	0.76	
Reading comprehension of everyday topics	0.68	0.72	
Speaking skills - general topics	0.70	0.83	
Speaking skills - specialized topics	0.73	0.80	
Improving pronunciation	0.53	0.61	.879
Factor 3: Casual and written communication in XR-supported contexts			
Everyday informal communication	0.73	0.61	
Writing informal texts	0.85	0.76	.814

Table 3. Exploratory factor analysis of the perceived usefulness of IDLE in developing ESP segments in XR-supported contexts

Factor 1 (Immersive academic and professional language use) brings together items related to specialized vocabulary, grammar and comprehension of discipline-specific content. In XR-supported contexts, such skills may be extended to simulations of professional tasks and field-specific learning environments. Factor 2 (Interactive comprehension and speaking skills) captures core oral and reading comprehension alongside speaking and pronunciation. These are central to XR-mediated communication, where embodied interaction can scaffold language practice in real-time. Factor 3 (Casual and written communication in XR-supported contexts) reflects informal messaging and everyday communication, which in XR-supported contexts may translate into spontaneous, peer-to-peer exchanges in virtual or augmented environments. Communalities ranged from .495 (learning general vocabulary and learning grammar) to .828 (speaking skills – general topics), indicating acceptable item representation in the factor solution. Cronbach's alpha values demonstrated acceptable to high internal consistency across all three factors.

3.3. Procedure and data analysis

The questionnaire was administered online via Google Forms. Participants were recruited by their language instructors through online classroom platforms and mailing lists. A total of nine incomplete responses were excluded from the final dataset prior to analysis.

Two sets of analyses corresponding to the research questions were conducted. To address RQ1, multiple regression models were performed with IDLE engagement factors as predictors and usefulness ratings as dependent variables. This allowed the identification of the types of IDLE practices that students perceived as most beneficial for different ESP language outcomes in XR-supported contexts. To address RQ2, hierarchical and K-means cluster analyses were conducted using IDLE factors to identify distinct learner engagement profiles. Subsequent ANOVAs with post-hoc comparisons tested whether these clusters differed in their usefulness ratings, thereby linking behavioral profiles of IDLE engagement to students' evaluative beliefs about ESP skill development.

4. RESULTS

4.1. Descriptive patterns of IDLE engagement and perceived usefulness

Before conducting inferential analyses, initial patterns in the data were examined to identify trends in students' engagement in IDLE practices (Table 4) and their perceptions of the usefulness of these practices for developing ESP-related competencies in XR-supported contexts (Table 5). The tables present mean scores, standard deviations and distributional indicators (skewness and kurtosis), providing an overview of the frequency, variability and distribution of responses across different types of digital English use.

(*How often do you use English when doing the following activities online?)*	Mean	SD	Skewness	Kurtosis
Social and interactive communication				
Talking with colleagues	1.69	0.79	1.685	2.63
Texting with colleagues	1.60	0.73	1.709	1.682
Talking with friends	2.56	1.11	0.483	-1.112
Texting with friends	2.47	1.12	0.545	-1.115
Reading posts/comments	3.63	1.15	-0.621	-1.133

Functional and informational literacy				
Online dictionaries	2.95	1.09	0.167	-1.259
Translation apps (EN → native)	2.97	1.05	0.248	-1.179
Translation apps (native → EN)	3.12	1.02	0.162	-1.204
English learning apps	1.83	0.94	1.407	0.836
Practice websites for English learning	2.31	1.12	0.708	-0.963
Technology-assisted and structured learning				
Watching tutorials (study-related)	3.92	0.99	-0.836	-0.588
Watching tutorials (for learning EN)	4.04	0.92	-0.969	-0.247
Watching tutorials (skills/knowledge)	2.33	1.07	0.691	-0.839
Listening to lectures in English	3.03	1.1	0.034	-1.317
Reading texts outside field	4.03	0.94	-0.981	-0.267
Media and academic content consumption				
Watching films/series (no subtitles)	4.05	0.91	-1.002	-0.102
Listening to news in English	3.04	1.14	-0.02	-1.402
Reading daily press in English	2.97	1.22	0.029	-1.569
Following podcasts in English	4.03	0.94	-0.981	-0.267
Watching sports in English	2.81	1.18	0.201	-1.455

Table 4. Overview of students' engagement in IDLE practices

A more detailed inspection of mean scores reported in Table 4 reveals clear differences in the frequency of specific IDLE practices. The highest levels of engagement were found for media and academic content consumption activities, particularly watching films/series without subtitles (M = 4.05) and following podcasts in English (M = 4.03), as well as reading texts outside one's field (M = 4.03) and watching tutorials for learning English (M = 4.04). These results suggest that students are highly engaged with English through content-oriented activities that provide rich input and combine both entertainment and knowledge acquisition. Similarly, relatively high levels of engagement were found for study-related tutorials (M = 3.92), indicating that this cohort of students frequently use English as a resource for self-directed learning. On the other hand, more moderate engagement was observed for activities such as listening to lectures in English (M = 3.03), listening to news (M = 3.04) and reading daily press (M = 2.97), suggesting that more formal or traditional forms of input are less consistently integrated into students' digital routines. Lower mean scores were associated with social and productive practices, particularly those involving communication with colleagues, such as talking with colleagues (M = 1.69) and texting with colleagues (M = 1.60). Slightly

higher, yet still moderate, engagement was observed for interaction with friends (talking with friends, M = 2.56; texting with friends, M = 2.47), indicating that English is not the dominant language of everyday interpersonal communication in these contexts. However, reading posts and comments (M = 3.63) stands out as a relatively frequent activity, which suggests that students are more likely to engage with English in receptive, socially mediated environments than in direct interaction. Within the domain of functional and informational literacy, activities such as using translation applications (M = 2.97–3.12) and online dictionaries (M = 2.95) were moderately frequent, whereas English learning apps (M = 1.83) and practice websites (M = 2.31) were used less often, suggesting that students tend to rely on English primarily as a support tool for comprehension, rather than engaging in structured, app-based language learning.

Table 5 shows the extent to which students believe IDLE practices are useful in helping them improve different ESP related competencies in XR-supported contexts.

(How beneficial is IDLE in improving the following ESP segments?)	Mean	SD	Skewness	Kurtosis
Immersive academic and professional language use				
Communication related to study area content	3.27	0.97	-0.245	-0.912
Learning specialized vocabulary	3.41	0.99	-0.322	-0.956
Comprehension of specialized oral communication	3.75	0.97	-0.641	-0.702
Reading comprehension of specialized topics	3.80	0.91	-0.543	-0.86
Learning general vocabulary	3.41	0.99	-0.322	-0.956
English grammar	3.60	0.87	-0.357	-0.711
Interactive comprehension and speaking skills				
Comprehension of everyday oral communication	4.27	0.82	-1.309	0.737
Reading comprehension of everyday topics	4.24	0.76	-1.112	0.298
Speaking skills – general topics	4.27	0.82	-1.309	0.737
Speaking skills – specialized topics	4.21	0.83	-1.181	0.373
Improving pronunciation	3.96	0.89	-0.875	-0.158
Casual and written communication in XR-supported contexts				
Everyday informal communication	4.33	0.76	-1.522	1.725
Writing informal texts	3.96	0.92	-0.893	-0.246

Table 5. Perceived usefulness of IDLE practices for developing ESP competencies

The results point to a clear pattern across different language competencies. The highest ratings were given to interactive and everyday communication skills,

especially everyday informal communication (M = 4.33), understanding everyday spoken communication (M = 4.27) and speaking on general topics (M = 4.27). Reading everyday texts (M = 4.24) and speaking in one's field of study (M = 4.21) were also rated highly. It appears that the participants in this study see IDLE as particularly useful for communication in familiar, everyday contexts, while also recognizing its relevance for more specialized use, although to a slightly lesser extent. In contrast, lower values were observed for more explicitly academic or professional uses of language, such as communication related to study area content (M = 3.27) and learning specialized vocabulary (M = 3.41). While these are still positively evaluated, they seem to be seen as less directly supported by IDLE. At the same time, receptive skills in specialized domains, such as reading (M = 3.80) and understanding spoken communication (M = 3.75), were rated relatively highly. This may suggest that IDLE is perceived as more helpful for comprehension than for production in academic contexts. Overall, the results point to a distinction between everyday, interaction-driven language use, which students clearly associate with digital practices, and more formal, discipline-specific competencies, which appear to be linked to more structured forms of learning.

4.2. IDLE practices as predictors of ESP competencies in XR-supported contexts

A multiple regression analysis was conducted to determine whether students' engagement in digital English practices predicted their perceived usefulness of IDLE for Immersive academic and professional language use (see Table 6). The results indicated that the overall model provided a good fit to the data, $F(4, 138) = 14.79$, $p < .001$, accounting for approximately 30% of the variance in the dependent variable ($R^2 = .30$). This represents a moderate effect size, suggesting that while IDLE engagement factors explain a meaningful portion of students' perceived ESP-related usefulness, other individual or contextual factors are also likely to contribute to their evaluations.

Predictor	B	SE B	β	t	*p*	95% CI for B
Constant	1.08	0.27	-	4.03	0.000	[0.55, 1.61]
Social and interactive communication	0.07	0.08	0.07	0.86	0.390	[-0.09, 0.24]
Functional and informational literacy	0.09	0.07	0.10	1.31	0.191	[-0.05, 0.23]
Technology-assisted and structured learning	0.39	0.09	0.39	4.39	0.000	[0.22, 0.57]
Media and academic content consumption	0.15	0.08	0.16	1.78	0.077	[-0.02, 0.31]

Table 6. IDLE as predictor of Immersive academic and professional language use

Among the four predictors, only Technology-assisted and structured learning emerged as a statistically significant predictor (β = .39, p < .001), indicating that students who frequently engaged with structured, technology-supported practices (e.g., tutorials, lectures, practice websites) also reported a stronger perceived development of immersive academic/professional skills. The other predictors did not reach statistical significance.

A second multiple regression analysis was conducted to examine whether students' engagement in digital English practices predicted their perceived usefulness of IDLE for Interactive comprehension and speaking skills (see Table 7). The model was statistically significant, F(4, 138) = 7.58, p < .001, accounting for 18% of the variance in the dependent variable (R^2 = .18). This indicates a small-to-moderate effect size, suggesting that students' digital English practices contribute to their perceptions of developing comprehension and speaking skills, although a considerable proportion of variance remains attributable to other factors beyond IDLE engagement.

Predictor	B	SE B	β	t	p	95% CI for B
Constant	2.07	0.27	-	7.57	0.000	[1.53, 2.61]
Social and interactive communication	0.10	0.08	0.10	1.14	0.255	[-0.07, 0.26]
Functional and informational literacy	0.03	0.07	0.04	0.48	0.634	[-0.11, 0.17]
Technology-assisted and structured learning	0.30	0.09	0.32	3.31	0.001	[0.12, 0.48]
Media and academic content consumption	0.07	0.08	0.07	0.79	0.430	[-0.10, 0.23]

Table 7. IDLE as predictor of Interactive comprehension and speaking skills

Of the four predictors, only the factor of Technology-assisted and structured learning was a significant predictor (β = .32, p = .001). Students who engaged more in structured, technology-supported activities (e.g., watching tutorials, lectures and using practice websites) reported greater perceived improvement in comprehension and speaking. The other predictors did not reach significance.

A final multiple regression analysis was conducted to test whether students' engagement in digital English practices predicted their perceived usefulness of IDLE for Casual and written communication in XR-supported contexts (see Table 8). The model was statistically significant, F(4, 138) = 10.41, p < .001, accounting for 23% of the variance in the dependent variable (R^2 = .23). This reflects a moderate effect size.

Predictor	B	SE B	β	t	*p*	95% CI for B
Constant	1.17	0.33	-	3.54	0.001	[0.51, 1.82]
Social and interactive communication	0.30	0.10	0.25	2.99	0.003	[0.10, 0.50]
Functional and informational literacy	0.10	0.09	0.09	1.19	0.237	[-0.07, 0.27]
Technology-assisted and structured learning	0.19	0.11	0.16	1.72	0.037	[-0.03, 0.41]
Media and academic content consumption	0.19	0.10	0.17	1.86	0.015	[-0.01, 0.39]

Table 8. IDLE as predictor of Casual and written communication in XR-supported contexts

Among the four predictors, Social and interactive communication (β = .25, *p* = .003) emerged as a strong positive predictor, indicating that informal peer communication in English meaningfully contributes to written and casual language use in XR-supported contexts. The factor of Technology-assisted and structured learning was also a significant predictor (β = .16, *p* = .037), although its contribution was more modest. Media and academic content consumption was also a significant predictor (β = .17, *p* = .015), though with a smaller effect size, while Functional and informational literacy was not significant (β = .09, *p* = .237).

4.3. Learner profiles based on IDLE engagement

In order to answer RQ2, a K-means cluster analysis was conducted on the four factors deriving from the exploratory factor analysis describing the participants' IDLE practices (see Table 9).

Variable	Cluster 1 (n = 32) Literate integrators	Cluster 2 (n = 63) Limited practice users	Cluster 3 (n = 48) Media-engaged communicators
Social and interactive communication	0.52	-0.58	0.41
Functional and informational literacy	1.25	-0.20	-0.57
Technology-assisted and structured learning	0.73	-0.81	0.57
Media and academic content consumption	0.49	-0.78	0.69

Table 9. Factor scores characterizing three clusters of IDLE practices

A three-cluster solution was selected based on the interpretability of the profiles, the distinctiveness of cluster centroids and supporting evidence from the

elbow method and explained variance, which together indicated that a three-group partition provided the most meaningful representation of the data. The three-cluster solution included 32 participants in Cluster 1, 63 in Cluster 2 and 48 in Cluster 3. Based on cluster means, Cluster 1 (Literate integrators) showed the highest scores on Functional and informational literacy, accompanied by above-average engagement in other domains. Literate integrators appear to approach IDLE as a resource for both learning and communication, combining structured practices with functional language use. These students are likely to engage with English purposefully, using it to access information, develop knowledge and participate in academically relevant activities. Cluster 2 (Limited practice users) demonstrated consistently below-average scores across all factors, indicating weaker involvement in IDLE practices. These users exhibit minimal engagement across all domains, suggesting that English plays a relatively peripheral role in their everyday digital routines. Their interaction with English appears to be occasional and situational rather than sustained or intentional, which may limit opportunities for development of both general language skills and study-related competencies. Cluster 3 (Media-engaged communicators) was distinguished by high media consumption, together with above-average social and technology-assisted learning practices. Media-engaged communicators seem to rely primarily on exposure to English through media and interaction, integrating language use into entertainment and socially driven activities. Their engagement is characterized by frequent contact with authentic input and communicative contexts, which may support fluency and adaptability, particularly in informal and interactional settings. ANOVA comparisons confirmed that all four dimensions significantly differentiated the clusters (all $p < .001$). A one-way ANOVA was conducted to compare ESP outcomes across the three clusters identified through K-means analysis. Results revealed significant differences in Immersive academic and professional language use ($F(2,140) = 25.037$, $p < .001$), Interactive comprehension and speaking skills ($F(2,140) = 10.778$, $p < .001$) and Casual and written communication in XR-supported contexts ($F(2,140) = 12.106$, $p < .001$). Post hoc Tukey tests indicated that Cluster 2 consistently scored significantly lower than Clusters 1 and 3 across all three domains. However, no significant differences were observed between Clusters 1 and 3. These results suggest a clear divide between limited XR users (Cluster 2) and more active XR users (Clusters 1 and 3).

5. DISCUSSION

The present study sought to identify the types of IDLE practices that students perceive as useful for developing ESP-related skills in XR-supported contexts and to determine how distinct IDLE engagement profiles relate to these perceptions. Two main research questions were addressed: (1) How do different types of IDLE practices relate to students' perceptions of the usefulness of IDLE for developing

specific ESP-related language skills?, and (2) How do distinct clusters of students differ in their perceptions of the usefulness of these practices for ESP development in XR-supported contexts based on their engagement in IDLE practices? The findings indicate that different aspects of informal learning relate differently to professional, academic and casual communication skills in English, reinforcing earlier claims about the multidimensional nature of IDLE (Kuru Gonen & Kızılay, 2023; Lee, 2019).

The regression analyses revealed that technology-assisted and structured learning – operationalized through activities such as watching study-related tutorials, listening to lectures in English and reading texts outside students' immediate field – was the most consistent predictor of perceived usefulness for immersive academic and professional communication. Given that the majority of participants came from the Faculty of Sciences and the Faculty of Technical Sciences, this pattern is not surprising. Students in these disciplines are regularly exposed to English-language manuals, software interfaces, technical documentation and research articles, and their academic development often depends on engaging with specialized English discourse (Cho & Lee, 2016; Hyland, 2017). They are also likely to come into contact with the latest technology and experiment with new tools and apps. Engaging with structured English content outside the classroom likely reinforces the specialized terminology and discourse conventions that they expect to encounter in XR-mediated laboratories, simulations or professional collaborations. In this sense, structured IDLE practices may function as a bridge between formal academic learning and technologically enhanced professional environments. Importantly, these findings suggest an association between structured IDLE practices and students' perceived development of ESP competencies, particularly in terms of discipline-specific vocabulary, discourse conventions and comprehension of specialized content (Jurkovič, 2019). When students watch tutorials or lectures in English, they are not merely consuming language input; they are rehearsing the discourse patterns that characterize their future professional communities. This indicates that IDLE practices are not only supportive, but constitutive of ESP development, as they enable students to internalize the linguistic and communicative norms of their fields. These results are consistent with previous research highlighting the pedagogical value of structured IDLE activities for formal language learning (Kuru Gonen & Kızılay, 2023; Lee, 2019), while extending them into the emerging XR context, where authenticity and multimodality are crucial.

In contrast, social and interactive communication – operationalized through items such as talking or texting with friends and colleagues in English and reading posts or comments online – emerged as the strongest predictor of perceived usefulness for casual and written communication in XR-supported contexts. Students who frequently engage in everyday peer interaction in English appear to associate these practices with communicative ease in informal, digitally mediated environments. This highlights the role of socially oriented IDLE practices in developing ESP-relevant communicative fluency, particularly in interactional and

collaborative dimensions of professional communication (Tasić & Stamenković, 2024), which is also consistent with research linking IDLE to increased willingness to communicate (Lee et al., 2024) and with interaction-based views of language use (García & Wei, 2014). As emphasized by Chen and Sevilla-Pavón (2023), XR platforms typically involve real-time collaboration, negotiation of meaning and rapid turn-taking in multimodal settings. For students accustomed to messaging, commenting and maintaining online exchanges in English, these environments may feel like a natural extension of their existing communication routines. Rather than perceiving XR as purely technological, they may experience it as an intensified version of familiar digital interaction. This aligns with Lee and Drajati's (2019) argument that IDLE fosters affective readiness and interactional competence. In XR-mediated spaces, such readiness likely translates into confidence in spontaneous, real-time interaction. The modest contribution of media consumption to casual communication further suggests that sustained exposure to authentic films, podcasts and news may enhance pragmatic awareness and adaptability, as authentic audiovisual input has been found to facilitate the development of L2 pragmatics and language learning (Abrams, 2014), both of which are qualities that are particularly valuable in multimodal collaborative settings.

Interestingly, functional and informational literacy practices, such as using dictionaries or translation apps, did not significantly predict ESP outcomes. Although these tools are useful for solving immediate language difficulties, students may not see them as contributing directly to their overall communicative competence or professional preparedness in immersive settings. This further suggests that not all forms of IDLE contribute equally to ESP development, with more passive or support-oriented practices playing a limited role in shaping discipline-specific communicative competence.

The findings also suggest that structured and socially driven IDLE practices play complementary roles. Structured engagement seems to help students develop clearer conceptual understanding and greater control of discipline-specific language, as indicated by Jurkovič (2019) and Kuru Gönen and Kızılay (2023), while socially driven and media-based practices help students become more flexible and responsive in dynamic, multimodal XR-supported interactions (Chen & Sevilla-Pavón, 2023). These findings indicate that ESP development in XR contexts is shaped by a combination of IDLE practices that support both specialized knowledge construction and interactive communicative competence.

The cluster analysis further clarifies this multidimensionality. Three distinct engagement profiles emerged: literate integrators, media-engaged communicators and limited practice users. Literate integrators demonstrated consistently high engagement across domains, particularly in literacy-oriented and structured practices. Media-engaged communicators showed particularly strong involvement in authentic media consumption and social interaction. Limited practice users reported comparatively low engagement across all factors. These profiles complement earlier IDLE research (Knežević & Topalov, 2025; Lee, 2019). The

present study, however, extends such typologies by linking them directly to perceived ESP development in XR-supported contexts. Both literate integrators and media-engaged communicators reported significantly higher perceived usefulness across all ESP domains compared to limited practice users. Importantly, there were no significant differences between the two more active clusters. This suggests that preparedness for XR-mediated communication does not depend on a single "ideal" type of informal engagement. Rather, different patterns of IDLE engagement appear to lead to similar ESP outcomes, highlighting the flexible and multifaceted nature of informal language development. What seems to be crucial is sustained and intentional participation in digital English practices, whether academically structured or socially oriented.

The Serbian university context provides an additional layer of interpretation. In subtitling-oriented media environments, such as the Serbian one, sustained exposure to English-language audiovisual content may create favorable conditions for informal language contact, and research has shown that subtitled original-version broadcasts are associated with stronger English proficiency than dubbed media (Micola et al., 2019). In the present study, activities such as watching films/series, following podcasts and engaging with other English-language digital content were among the more prominent forms of IDLE, which may help explain why media-engaged communicators perceived benefits in areas such as comprehension, vocabulary development and communicative confidence. Importantly, the results corroborate other research findings which indicate that sustained exposure to English through IDLE practices may contribute to perceived improvement in ESP competencies, particularly in terms of communicative flexibility (Lee & Drajati, 2019) and adaptability in professional contexts (Christou et al., 2025). At the same time, students in technical and scientific fields often rely on English-language resources for academic advancement. When structured learning and media-based engagement coexist, they may jointly contribute to ESP development, especially in immersive, technology-rich contexts like XR.

6. PEDAGOGICAL IMPLICATIONS

The findings indicate that ESP instruction may benefit from building on students' existing informal digital practices. In line with research emphasizing the pedagogical potential of informal digital learning environments (Kuru Gönen & Kızılay, 2023; Lee, 2019), XR-supported context should be approached not simply as a technological add-on, but as a communicative environment that connects with students' everyday digital experiences. This perspective is also consistent with the present findings, which show that both structured and socially oriented IDLE practices are associated with different aspects of ESP development. In practical terms, XR activities can be organized through a sequence of pre-task, task and post-task stages. The emphasis on structured preparatory activities reflects the role of

technology-assisted and structured learning identified in this study, which was the strongest predictor of academic and professional language use. For example, students might work with field-specific tutorials or recorded lectures in English before engaging in XR simulations such as project presentations or collaborative problem-solving tasks (Jurkovič, 2019). At the same time, incorporating opportunities for informal peer interaction aligns with the importance of socially oriented IDLE practices observed in the findings. Activities such as brief planning discussions, chat-based coordination, or peer feedback during or after XR-supported tasks may help create communicative conditions similar to those in students' everyday digital environments, which are associated with higher perceived usefulness for interactional and communicative skills (Lee, 2019). Designing XR-supported tasks in this way may increase students' sense of relevance and engagement, while helping bridge the gap between formal ESP instruction and everyday digital communication (cf. Burke et al., 2025; Dodds, 2021; Tunur et al., 2021). This is also in line with research on immersive learning environments, which highlights the importance of authenticity, multimodality and interaction in supporting communication in professional contexts (Chen & Sevilla-Pavón, 2023). If ESP instruction takes into account both structured learning and socially motivated digital practices, students may be better prepared for the communicative demands of XR-supported academic and professional work.

7. CONCLUSIONS

This study investigated how informal digital learning of English (IDLE) contributes to the development of ESP-related competencies in extended reality (XR) contexts, focusing on both perceived usefulness and patterns of learner engagement. The findings highlight that students do not engage with IDLE as a uniform construct; rather, they draw on distinct clusters of practices – ranging from structured, technology-assisted learning to socially driven communication and media-based exposure – that align with different dimensions of ESP skill development.

Over the three regression models, technology-assisted and structured learning emerged as the strongest predictor of perceived gains across immersive academic and professional communication and interactive comprehension and speaking skills. It appears that structured digital engagement, therefore, provides a foundation for mastering specialized vocabulary, discourse patterns and communicative demands typical of academic and professional domains in XR-supported contexts. By contrast, students' everyday digital interactions, such as messaging friends or participating in online discussions in English, were most closely linked to perceived gains in casual and written XR communication, reinforcing the importance of informal peer exchange in multimodal environments.

The cluster analysis further demonstrated that students differ meaningfully in how they engage with IDLE. Two clusters (literate integrators and media-engaged

communicators) reported substantially higher perceived usefulness of IDLE for ESP learning than limited practice users. Whether students primarily engaged with structured academic content or with socially and media-driven practices, both groups perceived meaningful ESP-related benefits, indicating that different forms of informal engagement may support readiness for XR-mediated communication. What seems to matter most is not the specific type of involvement, but the overall level of active and intentional participation in digital English practices.

Overall, the findings highlight the importance of including both structured and informal digital practices in ESP teaching, especially as XR becomes more common in professional and educational settings. Educators can enhance students' digital skills by creating activities that combine real-world XR-supported simulations with chances for informal peer interactions and media use. This approach can help students better manage the language, social and multimedia challenges they will face in future workplaces that use XR technologies.

While the study provides valuable insights, it relies on self-reported measures, which may be influenced by students' self-perceptions rather than actual language gains. Future research should triangulate self-report data with performance-based assessments and explore how specific IDLE practices interact with cognitive and affective variables such as self-regulation, enjoyment, or flow (Fang et al., 2025). Moreover, future research using longitudinal or experimental designs would allow for a better understanding of whether and how informal digital learning contributes directly to ESP development in XR-supported contexts. More comprehensive and XR-focused research designs could provide a clearer understanding of the role of IDLE in ESP learning.

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No generative AI tools were used to produce the research, data analysis, findings or explanations. *Grammarly* was used to check language and clarity. All ideas and interpretations in the paper are our own.

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Appendix

Survey* on Informal Digital Learning of English and perceived usefulness for ESP development in XR-supported contexts

*This is an English translation of the survey originally administered in Serbian.

Faculty:
Year of study:
Age:
Gender:
Please read each statement carefully and select the response that best reflects your usual experience. There are no right or wrong answers. We are interested in your honest opinions and habits. Please answer all items and choose only one response for each statement. All responses are anonymous and will be used for research purposes only. *How often do you engage in the following activities in English? Please rate on a scale from 1 to 5 (1 = I never do this, 2 = I rarely do this, 3 = I sometimes do this, 4 = I often do this, 5 = I always do this).*

Listening to lectures in English	1	2	3	4	5
Talking with colleagues in English	1	2	3	4	5
Reading texts outside your field in English	1	2	3	4	5
Texting with colleagues in English	1	2	3	4	5
Talking with friends in English	1	2	3	4	5
Watching films/series in English (without subtitles)	1	2	3	4	5
Texting with friends in English	1	2	3	4	5
Using English learning apps	1	2	3	4	5
Reading posts/comments in English	1	2	3	4	5
Listening to news in English	1	2	3	4	5
Watching tutorials for learning English	1	2	3	4	5
Reading daily press in English	1	2	3	4	5
Following podcasts in English	1	2	3	4	5
Watching sports in English	1	2	3	4	5
Watching study-related tutorials in English	1	2	3	4	5
Using online dictionaries in English	1	2	3	4	5
Using practice websites for English learning	1	2	3	4	5
Watching tutorials to develop skills/knowledge in English	1	2	3	4	5
Using translation apps (English into my native language)	1	2	3	4	5
Using translation apps (my native language into English)	1	2	3	4	5
How useful is the use of a mobile phone or a similar device for improving the following aspects of your English language knowledge and skills? Please rate on a scale from 1 to 5 (1 = Not useful at all, 2 = Slightly useful, 3 = Moderately useful, 4 = Quite useful, 5 = Very useful)					
English grammar	1	2	3	4	5
Speaking skills in my field of study	1	2	3	4	5
Everyday informal communication	1	2	3	4	5
Understanding everyday spoken communication	1	2	3	4	5
Reading comprehension of topics in my field of study	1	2	3	4	5
Speaking skills on general topics	1	2	3	4	5
Communication related to content in my field of study	1	2	3	4	5
Reading comprehension of everyday topics	1	2	3	4	5
Understanding spoken communication in my field of study	1	2	3	4	5
English pronunciation	1	2	3	4	5
General English vocabulary	1	2	3	4	5
Writing informal texts (messages, posts, comments)	1	2	3	4	5
Vocabulary in my field of study	1	2	3	4	5