

Multimodal Semiotic Resources in Online Learning Environments: Meaning-Making from an Applied Linguistics Perspective

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ABSTRACT

Purpose: This study examined how multimodal semiotic resources support meaning-making and comprehension in online applied linguistics learning.

Subjects and Methods: A convergent parallel mixed-methods design involved 120 applied linguistics students. The study examined five resources: text-based slides, video lectures, infographics, podcasts, and discussion forums. Quantitative data were collected through surveys, usage logs, and comprehension tests, while qualitative data were obtained through semi-structured interviews and observations of forum interactions. Quantitative analysis used descriptive statistics and Pearson correlation, whereas qualitative data were analyzed thematically and integrated.

Results: Positive associations were observed between resource use and comprehension. Text-based slides showed the strongest association ($r = .62$, $p < .001$), followed by video lectures ($r = .57$, $p < .001$), discussion forums ($r = .51$, $p = .002$), infographics ($r = .49$, $p = .003$), and podcasts ($r = .28$, $p = .04$). Comprehension scores were descriptively higher among students using three to four modalities and five modalities than among those using one to two modalities. Forum interactions supported reflection, peer exchange, and collaborative meaning-making.

Conclusions: Multimodal resources provide complementary opportunities for meaning-making in online applied linguistics learning. Strategic integration of resources and interactive activities can support comprehension, reflection, and collaborative learning.

INTRODUCTION

The rapid advancement of digital technologies has transformed the landscape of education, particularly in online learning environments (Roa et al., 2025; Kovtoniuk et al., 2022; Makda, 2025; García-Morales et al., 2021). With the proliferation of virtual classrooms, learning management systems, and synchronous and asynchronous communication tools, students and educators are increasingly relying on digital platforms for knowledge construction and communication. This shift necessitates a closer examination of how meaning is generated in digitally mediated contexts.

Online learning environments are inherently multimodal, encompassing textual, visual, auditory, and interactive elements that collectively contribute to knowledge construction (Al-Muttairi & Al-Alusi, 2025; Lumsden et al., 2024). In such contexts, communication extends beyond written language to include images, videos, gestures, animations, and other semiotic resources. These multimodal forms of communication shape learners' understanding and interpretation of content, emphasizing the complexity of meaning-making processes.

Sofkova (2017) said that, Semiotics, as the study of signs and meaning-making, provides a useful framework for analyzing communication in online learning environments. From an applied linguistics perspective, semiotic resources include both linguistic and non-linguistic modes through which participants convey, interpret, and co-construct meaning. According to Meyer et al. (2015), Understanding these resources allows researchers to examine how learners navigate and integrate multiple modes of representation.

Multimodal semiotic resources in education are not merely supplementary; they play a central role in scaffolding learning (Jones et al., 2020; Pacheco et al., 2021; Erfanian et al., 2019). For instance, visuals such as diagrams, infographics, and videos can support comprehension, particularly in complex topics where verbal explanations alone may be insufficient. According to Zheng et al. (2023) and Mohammadi et al. (2024) interactive features like polls, discussion forums, and collaborative documents foster engagement and co-construction of knowledge.

The concept of multimodality, as discussed by Kress & van (2002), highlights that meaning is distributed across multiple modes, each with its own affordances and constraints. In online learning, educators often design content that strategically combines textual, visual, and auditory resources to optimize learning outcomes (Meng & Hong, 2024; Grant, 2021). The analysis of these resources can reveal how meaning is orchestrated and negotiated in digital classrooms.

Applied linguistics provides the theoretical lens to explore these phenomena, focusing on language use, discourse, and the interaction between linguistic and non-linguistic resources (Flowerdew, 2012). By integrating multimodal analysis with applied linguistics, researchers can investigate how learners interpret and produce meaning through diverse semiotic channels, including text, speech, image, and digital artifacts.

The proliferation of online learning during the COVID-19 pandemic has accelerated interest in multimodal communication and meaning-making (Pedrazzini et al., 2023). Educators have had to adapt their teaching strategies to accommodate learners who access content through multiple devices, platforms, and modalities (Ulanday et al., 2021; Huda, 2024; Moorhouse & Wong, 2022; Sato et al., 2023). Consequently, understanding the interplay of semiotic resources has become critical for enhancing instructional design and promoting effective learning.

Several studies have examined multimodal practices in online education, highlighting how learners use semiotic resources to express understanding, negotiate meaning, and construct knowledge collaboratively (Satar et al., 2023). For example, students may use text-based discussion posts, video presentations, digital drawings, and emojis to communicate ideas. Each mode contributes differently to meaning-making, reflecting learners' agency and interpretive choices.

Online learning environments often blur the distinction between formal and informal learning. Learners engage with content through structured assignments, but they also participate in social interactions, collaborative projects, and peer feedback activities (Zitha et al., 2023). These interactions involve multimodal communication that extends the semiotic landscape, providing opportunities to analyze how meaning is co-constructed across contexts.

The integration of multimodal semiotic resources in online learning also raises questions about accessibility and inclusivity. Wulan et al. (2022) said that, different learners may have varying levels of proficiency with specific modes, and the affordances of digital platforms can either support or constrain participation. An applied linguistics approach allows researchers to examine these dynamics, highlighting how linguistic and semiotic competence shapes engagement and learning outcomes.

Another important consideration is the role of culture and context in shaping multimodal meaning-making. Semiotic resources are culturally situated; images, gestures, colors, and symbols can carry different interpretations depending on learners' backgrounds. Online learning environments, particularly those with international participation, necessitate sensitivity to such semiotic diversity to ensure effective communication and understanding.

From an educational perspective, analyzing multimodal resources can inform instructional design by identifying which combinations of modes enhance comprehension, engagement, and

knowledge retention. Teachers can strategically employ text, visuals, audio, and interactive tools to scaffold learning, accommodate diverse learner needs, and foster creativity in knowledge production (Chisunum & Nwadiokwu, 2024).

Multimodal analysis can reveal the implicit rules and patterns that govern meaning-making in digital contexts (Martin et al., 2021; Twiner et al., 2021; Nielsen et al., 2022). By examining how learners organize, sequence, and integrate semiotic resources, researchers can uncover the cognitive and social processes underlying online learning. This contributes to a deeper understanding of how learners interpret content, collaborate, and develop digital literacy skills.

Despite the growing body of research, studies integrating applied linguistics and multimodal semiotics in online learning remain limited, particularly in contexts beyond formal institutional settings. There is a need for empirical investigations that capture the richness and complexity of multimodal practices, providing insights into how learners and educators negotiate meaning in digitally mediated educational spaces.

Understanding multimodal semiotic resources in online learning environments is critical for enhancing meaning-making, engagement, and learning outcomes. From an applied linguistics perspective, this study examines how learners use linguistic and non-linguistic modes to construct knowledge, navigate digital platforms, and participate in collaborative learning. By analyzing the interplay of semiotic resources, this research aims to provide theoretical and practical insights into effective teaching and learning in online education.

METHODOLOGY

Research Design and Participants

This study employed a convergent parallel mixed-methods design to examine the use of multimodal semiotic resources in an online applied linguistics learning environment and their relationship with students' meaning-making and comprehension. Quantitative and qualitative data were collected within the same academic semester, analyzed separately, and subsequently integrated to provide a comprehensive interpretation of students' engagement with multimodal learning resources. The quantitative component examined resource usage, perceived effectiveness, comprehension outcomes, and discussion forum participation, whereas the qualitative component explored students' experiences, learning strategies, preferences, and challenges in using different multimodal resources. The study involved 120 undergraduate students enrolled in an applied linguistics program. All participants engaged in an online learning environment in which five types of multimodal resources were incorporated into instructional activities: text-based slides, video lectures, infographics, podcasts, and discussion forums. Students interacted with these resources both individually and in combination throughout one academic semester. The study therefore examined multimodal learning within an authentic online applied linguistics context rather than under an experimentally controlled condition.

Data Collection

Data were collected from multiple sources to capture both measurable patterns of engagement and students' experiences with multimodal learning. Quantitative data were obtained through student surveys, system-generated usage logs, and comprehension tests. The survey used a Likert-scale format to assess students' perceived effectiveness of the different learning modalities. Usage logs recorded students' engagement with the online resources, including frequency of access, duration of use, and participation in discussion forums. Comprehension tests were administered to assess students' understanding and application of linguistic concepts presented through the online learning materials. Qualitative data were collected through semi-structured interviews and observation of discussion forum interactions. The interviews explored students' learning strategies, preferences, experiences, and challenges associated with the use of different multimodal resources. Forum observations focused on naturally occurring peer interactions, including clarification of ideas, peer feedback, negotiation of meaning, and collaborative knowledge construction. The combination of these data sources enabled the study to examine multimodal learning from both students' reported experiences and their observed online interactions.

Quantitative Data Analysis

Quantitative data were analyzed using descriptive statistics and Pearson correlation analysis. Frequencies and percentages were used to describe the frequency of students' engagement with text-based slides, video lectures, infographics, podcasts, and discussion forums. Means and standard deviations were calculated to examine students' perceived effectiveness of each learning resource. Pearson correlation analysis was used to examine the relationships between the frequency of engagement with each multimodal resource and students' comprehension scores. The analysis produced correlation coefficients and corresponding p-values to identify the direction, strength, and statistical significance of the observed relationships. The comprehension scores were also compared descriptively according to the number of multimodal resources used by students. The analysis distinguished three categories of multimodal engagement: 1–2 modalities, 3–4 modalities, and 5 modalities. The corresponding mean comprehension scores, standard deviations, and group sizes were used to describe patterns of comprehension across different levels of multimodal engagement.

Qualitative Data Analysis

Qualitative data from the semi-structured interviews and discussion forum observations were analyzed using thematic analysis. The analysis was conducted iteratively by reviewing the interview and forum data, identifying meaningful segments, assigning initial codes, grouping related codes, and developing broader themes relevant to multimodal learning and meaning-making. The coding process focused on recurring patterns concerning students' experiences with different learning modalities, strategies for combining resources, perceived benefits, learning challenges, peer interaction, and collaborative meaning-making. The emerging themes were reviewed against the qualitative data and subsequently interpreted in relation to the quantitative findings. Particular attention was given to how students combined multiple modalities and how different resources contributed to comprehension, reflection, interaction, and learning engagement.

Integration of Quantitative and Qualitative Findings

The quantitative and qualitative findings were integrated during the interpretation stage through triangulation across data sources. Quantitative patterns concerning resource usage, perceived effectiveness, comprehension, and forum participation were compared with qualitative evidence from interviews and discussion forum interactions. For example, quantitative findings concerning the frequent use and high perceived effectiveness of text-based slides and video lectures were interpreted alongside students' descriptions of how these resources supported organization, explanation, pronunciation, intonation, and understanding of linguistic concepts. Similarly, quantitative evidence concerning discussion forum participation was considered together with qualitative evidence of peer interaction, reflection, clarification, and negotiation of meaning. This integration enabled the study to identify areas of convergence and complementarity between measurable learning patterns and students' reported experiences.

Ethical and Interpretive Considerations

The study interpreted the quantitative findings as associations rather than causal effects, given the observational and correlational nature of the quantitative analysis. Accordingly, relationships between multimodal resource use and comprehension were interpreted in terms of observed patterns rather than direct causal effects. Qualitative findings were used to provide contextual explanations for these patterns and to clarify how students experienced and interpreted the use of different multimodal resources.

RESULTS AND DISCUSSION

This study investigated the use of multimodal semiotic resources in online learning environments among undergraduate applied linguistics students and how these resources support meaning-making. A total of 120 students participated in the study, interacting with text-based slides, video lectures, infographics, podcasts, and discussion forums. Data were collected through surveys, usage logs, semi-structured interviews, and observation of forum interactions. Mixed-method analysis was applied to explore both the frequency of use and perceived effectiveness of each

modality, as well as students' qualitative experiences. The first step in the analysis was to quantify students' engagement with each resource type. Table 1 presents the frequency of resource use, which highlights the centrality of slides and videos in students' learning routines.

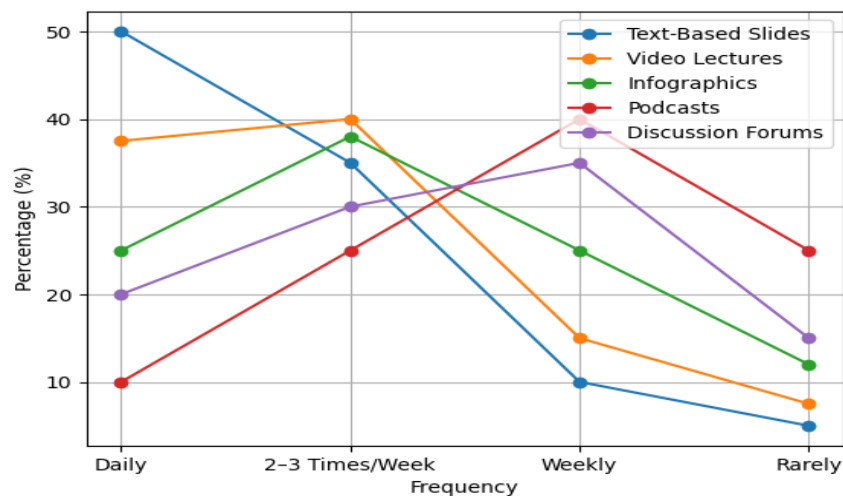


Figure 1. Frequency of Use of Multimodal Resources (n = 120)

The data indicate that text-based slides and video lectures were the most frequently used resources, reflecting their central role in students' online learning activities. In contrast, podcasts were used less frequently, particularly because they provided fewer visual cues for understanding abstract linguistic concepts. Interview findings further indicated that students relied on slides to organize learning materials, while video lectures supported their understanding of pronunciation, intonation, and other multimodal cues. To examine students' perceptions of the effectiveness of each resource, mean scores and standard deviations were calculated using a five-point Likert scale. Table 1 presents the perceived effectiveness of the five multimodal resources.

Table 1. Perceived Effectiveness of Multimodal Resources (1 = Least Effective, 5 = Most Effective, n = 120)

Resource Type	Mean Score	SD
Text-Based Slides	4.27	0.63
Video Lectures	4.08	0.72
Infographics	3.79	0.80
Podcasts	3.08	0.90
Discussion Forums	3.42	0.85

Source: Primary data from student survey, processed by the authors (2026)

The results show that text-based slides received the highest perceived effectiveness score ($M = 4.27$, $SD = 0.63$), followed by video lectures ($M = 4.08$, $SD = 0.72$). Infographics received a mean score of 3.79 ($SD = 0.80$), while discussion forums recorded a mean score of 3.42 ($SD = 0.85$). Podcasts obtained the lowest mean score ($M = 3.08$, $SD = 0.90$). Qualitative findings indicated that infographics were useful for summarizing grammar rules and lexical relationships, whereas discussion forums facilitated reflective and collaborative learning. Podcasts were generally perceived as supplementary resources, particularly for listening practice. These findings were subsequently examined in relation to the association between resource usage and students' comprehension scores.

Table 2. Correlation Between Resource Use and Comprehension (n = 120)

Resource Type	r	p-value
Text-Based Slides	0.62	<0.001
Video Lectures	0.57	<0.001
Infographics	0.49	0.003
Podcasts	0.28	0.04

Discussion Forums	0.51	0.002
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Source: Primary data from learning usage logs and comprehension tests, processed by the authors (2026)

Table 2 illustrates that slides and videos have the strongest positive correlations with comprehension, while podcasts show a weak correlation. This supports the qualitative findings that visual and auditory integration enhances meaning-making, whereas audio-only resources are less effective without accompanying visual cues. To explore modalities' impact on collaborative learning, students were asked about their use of discussion forums for negotiation of meaning. The forum participation data provide an overview of students' online interaction and engagement during the 10-week learning period. As presented in Table 3, students contributed an average of 5.6 posts (SD = 2.3) and 8.2 replies (SD = 3.1) per student. The number of posts ranged from 1 to 12, while replies ranged from 2 to 18. Students' posts contained an average of 65.4 words (SD = 20.5), with post length ranging from 30 to 120 words. The average response time was 12.3 hours (SD = 4.5), ranging from 2 to 24 hours.

Table 3. Forum Participation Statistics (n = 120)

Metric	Mean	SD	Min	Max
Number of posts per student	5.6	2.3	1	12
Number of replies per student	8.2	3.1	2	18
Average words per post	65.4	20.5	30	120
Average response time (hours)	12.3	4.5	2	24

Source: System-generated learning management system usage logs, processed by the authors (2026)

The distribution of forum activity indicates that students participated in both initiating discussions and responding to their peers. The higher mean number of replies than posts suggests that students engaged not only in posting their own ideas but also in responding to existing contributions. The observed variation in post frequency, reply frequency, post length, and response time further indicates differences in the intensity and timing of students' participation. These quantitative patterns were complemented by qualitative observations of forum interactions, which focused on peer feedback, clarification of ideas, reflection, and negotiation of meaning. Qualitative data suggest that students engage in reflective discussion and clarification of complex concepts:

"When I post my explanation, classmates reply with suggestions. It helps me see different perspectives." (Student, S45)

The data and qualitative insights from Table 4 suggest that discussion forums serve as a dynamic space for collaborative meaning-making in the online learning environment. Students actively interact not only to share their own ideas but also to respond to peers' contributions, indicating a reciprocal process of knowledge construction. The interview quote from Student S45 highlights how forum participation fosters reflection and exposure to multiple perspectives, which aligns with the applied linguistics principle that understanding emerges through dialogue and negotiation of meaning. This demonstrates that forums act as more than a communication channel; they become semiotic spaces where language, ideas, and reasoning are co-constructed collectively.

Beyond cognitive engagement, forum discussions appear to encourage metacognitive awareness among students. By reflecting on peers' feedback and integrating alternative viewpoints, learners become more aware of the strengths and limitations of their own arguments, which contributes to deeper comprehension of complex linguistic concepts. Moreover, the asynchronous nature of forums allows students time to formulate thoughtful responses, balancing immediacy with deliberation, and creating opportunities for scaffolded learning through peer interaction. This reflective component is particularly valuable in applied linguistics, where understanding abstract theoretical principles often requires discussion and exemplification.

Instructors reported that forums also serve as diagnostic tools, providing insight into students' levels of understanding and misconceptions. Patterns in responses reveal areas where additional clarification or targeted instruction may be necessary. Consequently, forums function as both a learning modality and an assessment mechanism, bridging formal teaching and peer-to-peer learning. The combination of quantitative engagement and qualitative reflection underscores the forum's role as a critical semiotic resource, mediating knowledge through textual, interpretive, and interactive means.

The observed peer-to-peer negotiation contributes to a supportive online learning community. Students reported feeling more confident to contribute when they perceived that peers were engaged and responsive, which reinforces participation and sustains interaction over time. This social dimension of forum activity illustrates how multimodal semiotic resources—textual communication, feedback, and peer scaffolding interact to create meaningful learning experiences that extend beyond content mastery to include collaborative competencies, reflective thinking, and autonomous learning practices. This emphasizes the importance of collaborative semiotic resources in reinforcing learning. Next, the study analyzed students' integration of multiple modalities. Table 4 shows the relationship between the number of modalities used per week and comprehension assessment scores.

Table 4. Comprehension Scores by Number of Modalities Used

Number of Modalities Used	Mean Score (0–100)	SD	n
1–2	73.5	6.2	32
3–4	87.3	5.5	58
5	91.5	4.8	30

Source: Primary data from comprehension tests and multimodal resource usage, processed by the authors (2026)

Table 4 demonstrates a clear trend: students who actively combine three or more resources achieve higher comprehension, confirming that multimodal integration supports deeper meaning-making. Interviews reinforced this observation:

"I watch videos, follow slides, check infographics, and then discuss in forums. This combination helps me understand much better than any single resource." (Student, S12)

The results in Table 4 indicate that students' comprehension improves as they engage with a greater number of modalities, suggesting that multimodal learning promotes richer and more effective meaning-making. Students who used three or more resources consistently scored higher, which implies that the integration of different semiotic tools such as videos, slides, and infographics supports multiple channels of cognitive processing and reinforces understanding. The interview from Student S12 underscores this pattern, showing that learners perceive added value in combining visual, textual, and interactive materials, which enables them to connect concepts more effectively than relying on a single modality.

Moreover, these findings highlight the role of learner agency in selecting and integrating resources according to personal preferences and learning needs. By actively combining modalities, students not only access complementary representations of information but also engage in reflective and self-directed learning, enhancing both comprehension and retention. This trend suggests that designing online learning environments that provide diverse and integrated semiotic resources can foster deeper engagement and more meaningful learning experiences, aligning with applied linguistics perspectives on multimodal meaning-making. Table 6 summarizes qualitative feedback on challenges and preferences associated with each modality, integrating insights from both students and instructors.

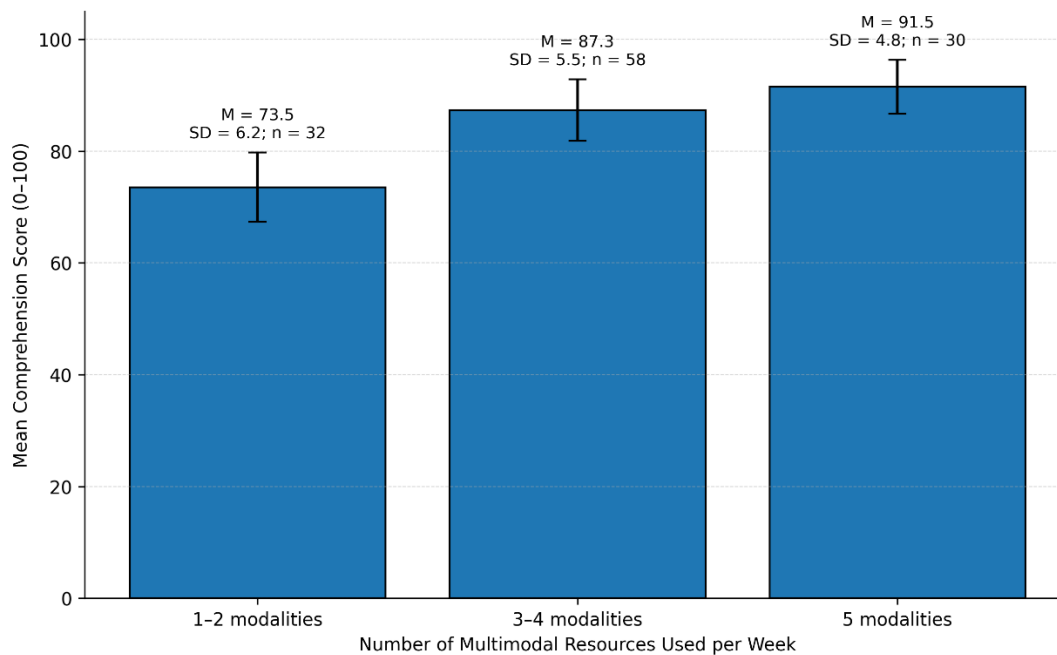


Figure 2. Comprehension Scores by Number of Multimodal Resources Used per Week

Figure 2 illustrates the descriptive pattern between the number of multimodal resources used per week and students' comprehension scores. Students who used 1–2 modalities recorded a mean comprehension score of 73.5 (SD = 6.2, n = 32), whereas those who used 3–4 modalities achieved a higher mean score of 87.3 (SD = 5.5, n = 58). The highest mean score was observed among students who used all five modalities, with a mean of 91.5 (SD = 4.8, n = 30). The descriptive pattern shows progressively higher comprehension scores across the three levels of multimodal engagement. However, because the analysis reported in this study is descriptive for these groups, the pattern should be interpreted as an observed association rather than evidence of a causal effect or statistically significant difference between groups.

"I usually start with slides because they help me organize the material clearly, and then I watch the videos to understand the examples better. The combination really supports my understanding, especially for difficult topics like syntax and discourse. However, sometimes I feel that relying too much on slides makes me less active in thinking critically. When I use infographics, they help me summarize key points, but I still need other resources to fully grasp the concepts. For me, each resource has its own role, and I need to combine them to really understand the material." (Student, S14)

This aligns with the identified benefits of slides as organizational tools and their associated challenge of reducing active thinking. Additionally, the student's reference to infographics as supportive but insufficient on their own confirms that certain modalities function more effectively as supplementary resources rather than primary sources of understanding.

"I find discussion forums very useful because I can interact with my classmates and see different perspectives on the same topic. When I don't understand something, reading others' explanations really helps me clarify my ideas. But sometimes it takes a lot of time to read all the posts and respond thoughtfully. I also use podcasts for listening practice, but I often struggle when the content is too abstract without visual support. That's why I prefer combining videos and forums, because I can both see examples and discuss them with others. This combination makes learning more engaging and meaningful for me." (Student, S33)

At the same time, it acknowledges the time-intensive nature of active participation, reflecting the challenges identified in figure 2. The student's experience with podcasts further supports the finding that audio-only resources can be difficult to follow without visual reinforcement, particularly for abstract linguistic content. Importantly, both excerpts underscore a consistent theme: effective learning emerges from the integration of multiple modalities rather than reliance

on a single resource. This reinforces the study's broader argument that multimodal engagement enhances comprehension by enabling students to process information through complementary cognitive and social pathways.

The feedback also underscores the importance of designing online courses that balance structured guidance with opportunities for active participation. While resources like slides and infographics provide clarity and organization, interactive elements such as discussion forums enable reflection and collaborative problem-solving, and dynamic tools like videos and podcasts support engagement with authentic, context-rich language input. Collectively, these modalities enhance comprehension, promote cognitive processing, and allow learners to negotiate meaning in ways that reflect real-world language use. In essence, effective online learning environments depend on thoughtfully combining modalities to support diverse learning needs, foster active engagement, and facilitate deeper understanding.

Discussion

Multimodal Resource Use and Students' Comprehension

The findings suggest that the relationship between multimodal resource use and comprehension is shaped by the particular affordances of each semiotic mode rather than by the mere presence of digital materials. Text-based slides and video lectures demonstrated the strongest positive associations with comprehension, while infographics, discussion forums, and podcasts showed progressively weaker associations. This pattern is theoretically consistent with the Cognitive Theory of Multimedia Learning, which proposes that meaningful learning depends on how learners select, organize, and integrate information across verbal and visual processing systems rather than simply receiving information through multiple channels (Mayer, 2024). The relatively strong association observed for slides may reflect their function as stable organizational scaffolds that allow students to review terminology, concepts, and explanations at their own pace. Video lectures, in contrast, provide temporal sequencing and audiovisual cues that may be particularly relevant to applied linguistics, where pronunciation, intonation, discourse, and contextualized language use are difficult to represent through static text alone. Recent research similarly indicates that well-designed instructional videos can support generative learning processes and subsequent academic performance when learners actively process the presented information (How students' achievement goals, 2023).

This finding agrees with research emphasizing the pedagogical value of combining textual, visual, and auditory representations in online learning, but it also qualifies the assumption that all modalities contribute equally. Ongor and Uslusoy (2023), for example, reported positive outcomes associated with multimedia-based e-learning, while Cavanagh and Kiersch (2023) emphasized that multimedia effectiveness depends on deliberate instructional design rather than technological richness alone. A systematic review by Meng et al. (2024) likewise found that online learning effectiveness varies according to instructional design, interaction, infrastructure, and the way learning effectiveness is measured. The present study extends these discussions by showing that modality-specific patterns can be observed within a single applied linguistics learning environment.

Theoretically, the contribution lies in connecting multimodal semiotic resources with applied linguistics meaning-making rather than treating multimedia simply as an instructional technology. Practically, the findings suggest that instructors should assign distinct pedagogical functions to different resources. Slides may provide conceptual structure, videos may contextualize language and provide audiovisual exemplification, infographics may condense relationships among concepts, and podcasts may provide additional listening exposure. The weaker association observed for podcasts should therefore not be interpreted as evidence that audio learning is inherently ineffective. Instead, the qualitative evidence suggests that audio-only materials may require complementary visual or textual support when students encounter abstract linguistic concepts. This interpretation contributes to the study's novelty by positioning modality effectiveness as function-dependent and context-sensitive, rather than as a universal hierarchy of digital resources.

Multimodal Integration and Comprehension in Online Applied Linguistics Learning

The descriptive pattern across the three levels of multimodal engagement provides a second important contribution. Students using 1–2 modalities recorded a mean comprehension score of 73.5, compared with 87.3 among those using 3–4 modalities and 91.5 among those using all five modalities. The interpretation of this pattern should remain descriptive because the study did not conduct an inferential test comparing these groups. Nevertheless, the progressively higher scores provide evidence that broader engagement with complementary semiotic resources is associated with higher comprehension within this sample. The qualitative account from Student S12 strengthens this interpretation by describing a sequence involving videos, slides, infographics, and discussion forums rather than reliance on a single resource.

This pattern corresponds with contemporary research arguing that multimodal learning becomes meaningful when learners actively integrate representations rather than merely encounter multiple media formats. Mayer (2024) explains that meaningful multimedia learning requires active selection, organization, and integration of verbal and visual information. Cavanagh and Kiersch (2023) similarly emphasize that online multimedia environments are most productive when instructional technologies are aligned with cognitive principles. Research in language education further indicates that digital multimodal practices can expand learners' awareness of how different modes contribute distinct communicative functions (Di Zhang & Yu, 2023; Jiang & Hafner, 2024). Ho (2024) likewise found that students exposed to digital multimodal composing developed greater awareness of the affordances and constraints of different modes and learned to connect classroom and out-of-class digital practices.

The present findings are therefore consistent with prior studies but differ in one important respect. Much of the recent literature examines multimodality through production activities, digital composing, or specific multimedia interventions. This study instead examines students' naturally occurring integration of five different resources within an online applied linguistics course. The contribution is consequently not that more media automatically produce better learning, but that students appear to benefit when resources perform complementary semiotic functions. Slides can organize concepts, videos can contextualize explanations, infographics can condense relationships, podcasts can provide listening exposure, and forums can enable dialogic elaboration. Such complementarity offers a theoretical extension of multimodal learning by connecting cognitive processing with semiotic orchestration and learner agency.

The practical implication is that online course design should avoid simply accumulating digital materials. Instructors should construct meaningful pathways among resources so that each modality addresses a distinct learning function. A grammar concept, for instance, can be introduced through structured slides, contextualized through video examples, condensed through an infographic, reinforced through listening material, and subsequently discussed in a forum. This sequencing may encourage students to move from reception toward interpretation and interaction. The novelty of the study lies in conceptualizing multimodality as an integrated meaning-making ecology, where learning value emerges from relationships among resources rather than from isolated media effects.

Discussion Forums, Peer Interaction, and Collaborative Meaning-Making

The forum findings demonstrate that multimodal learning in applied linguistics extends beyond the consumption of instructional content to include interactional meaning-making. Students produced an average of 5.6 posts and 8.2 replies, indicating that participation involved both initiating ideas and responding to peers. The qualitative evidence provides an important interpretive dimension to these participation patterns. Student S45 explained that classmates' suggestions helped the student see “different perspectives,” illustrating how forum interaction created opportunities to reconsider and elaborate previously expressed ideas. The significance of this finding lies less in the number of posts itself than in the dialogic function of those interactions.

This interpretation is consistent with contemporary research on online collaborative learning. Guo et al. (2022) demonstrate that online discussions can facilitate social presence and social knowledge construction, while Kumi (2023) argues that discussion forums should be examined

not only through participation counts but also through the relational structure of interactions. Burke et al. (2025) similarly emphasize that asynchronous discussion boards can reveal different forms of cognitive engagement through students' written contributions. Research in language-learning contexts also supports the value of asynchronous discussion for exchanging ideas, feedback, and clarification (Nacionales, 2023). Recent research on asynchronous video discussions further demonstrates that peer responses can support cognitive presence and co-construction of knowledge among language learners.

At the same time, the present findings add an important qualification. The forum should not be conceptualized as automatically producing meaningful collaboration. Recent evidence indicates that interaction quality depends on task structure, participation patterns, and the pedagogical organization of digital activities. Bach and Thiel (2024) found that collaborative online learning involves cognitive, metacognitive, and relational dimensions of interaction, while Hidayat (2025) reported that asynchronous participation can decline over time when interaction and self-regulation are insufficient. Recent work on MOOC forums similarly shows that forum design can influence the depth and character of collaborative knowledge construction. These findings help explain why the present study's combination of posts, replies, and qualitative evidence is more informative than participation frequency alone.

The theoretical contribution is that discussion forums can be conceptualized as interactive semiotic spaces in which language, interpretation, feedback, and perspective-taking become resources for knowledge construction. This extends a purely cognitive interpretation of multimodal learning by emphasizing the social and dialogic dimensions of meaning-making. Practically, instructors should design prompts that require explanation, comparison, clarification, and response to peers rather than simple opinion posting. Structured response requirements, explicit discussion purposes, and appropriate instructor presence can help transform forums from communication spaces into learning spaces. The study's novelty therefore lies in linking quantitative forum participation with qualitative evidence of perspective-taking and negotiation of meaning within an applied linguistics context.

Theoretical and Practical Implications

Taken together, the findings support a view of online applied linguistics learning in which comprehension is associated with both multimodal representation and social interaction. The results complement cognitive explanations of multimedia learning by demonstrating that meaning-making does not occur solely through the processing of text, images, and audio. It also develops through learners' decisions about how to combine resources and through interaction with peers. Contemporary research on digital multimodal composing similarly emphasizes that learners make strategic choices among modes rather than passively receiving multimodal information (Jiang & Hafner, 2024; Ho, 2024). Research on digital multimodal composing in tertiary language classrooms also identifies opportunities for collaboration, communication, and expanded literacy practices (Zhang et al., 2024).

The theoretical implication is that multimodal semiotic resources should be understood as an interconnected learning ecology. The study contributes to applied linguistics by showing that meaning-making involves the interaction of linguistic, visual, auditory, and dialogic resources. This perspective complements research on multimodal interaction in English-medium instruction, which demonstrates that participation in digital environments is shaped by how instructors coordinate multiple communicative modes (Querol-Julián, 2023). It also corresponds with research using multimodal learning analytics, which demonstrates that online learning processes can be examined through multiple forms of behavioral and interactional evidence rather than through achievement scores alone (Wang et al., 2023).

The practical contribution is particularly relevant for higher education instructors designing online applied linguistics courses. The findings suggest that resource selection should be guided by pedagogical function. Structured textual materials can support orientation and review, audiovisual materials can provide contextualized language input, visual summaries can consolidate complex relationships, audio materials can support listening development, and discussion forums can create opportunities for dialogic interpretation. Such integration should be

intentional rather than excessive because multimedia environments may also generate cognitive demands when information is poorly coordinated. The instructional goal is therefore not to maximize the number of media formats but to create meaningful connections among them.

The study also contributes a learner-agency perspective. Students in the qualitative data did not describe multimodality simply as a collection of teacher-provided materials. They described selecting and combining resources according to perceived learning needs. This corresponds with recent work showing that digital multimodal practices can increase learners' awareness of the affordances and constraints of different modes (Ho, 2024). The novelty of the present study consequently lies in integrating modality-specific affordances, multimodal integration, and peer-mediated meaning-making within one applied linguistics learning environment. This integrated interpretation provides a more comprehensive explanation of online meaning-making than approaches that examine individual technologies separately.

Limitations of the Study

Several limitations should be considered when interpreting the findings. First, the study involved 120 undergraduate applied linguistics students within a single online learning context. The sample provides meaningful evidence concerning the studied learning environment, but the findings should not be generalized automatically to other disciplines, educational levels, institutional contexts, or learner populations. Research on online learning demonstrates substantial variation in effectiveness according to instructional design, infrastructure, interaction, and contextual conditions, suggesting that multimodal practices may operate differently across educational settings (Meng et al., 2024).

Second, the quantitative analysis relied primarily on descriptive statistics and Pearson correlations. Consequently, the positive associations between resource engagement and comprehension should not be interpreted as causal relationships. Students who engage more frequently with particular resources may differ from less-engaged students in motivation, prior knowledge, self-regulation, digital competence, or other characteristics that were not modeled in the present analysis. This limitation is particularly relevant because online learning requires substantial learner autonomy and self-regulatory capacity. The study therefore identifies meaningful patterns of association rather than experimentally established effects.

Third, the comparison of comprehension across 1–2, 3–4, and 5 modalities is descriptive. Although the mean scores show a progressively higher pattern, the study did not employ ANOVA, regression, or another inferential procedure to determine whether differences between groups were statistically significant. The interpretation should therefore remain cautious. Future studies could incorporate longitudinal or quasi-experimental designs to distinguish the contribution of multimodal integration from pre-existing differences among learners.

Fourth, the qualitative component provides valuable contextual evidence but does not report a sufficiently detailed account of the number of interview participants or the distribution of qualitative codes in the current manuscript. This limits the extent to which the qualitative themes can be evaluated for breadth and saturation. Future mixed-methods research should report participant selection for interviews, coding procedures, coder agreement where applicable, and the distribution of themes more systematically. Such reporting would strengthen methodological transparency and enable closer comparison with other multimodal learning studies.

Future Research Directions

Future research should move beyond cross-sectional associations toward designs capable of examining how multimodal engagement develops over time. Longitudinal research could track students' resource-selection patterns across several courses or semesters and examine whether changes in multimodal strategies correspond with changes in comprehension, retention, and language-related competencies. This would address an important limitation of the current study by distinguishing stable learner preferences from patterns that emerge through instructional experience.

A second direction is to examine modality combinations rather than simply counting the number of resources used. The current findings suggest that students who engage with three or more

modalities demonstrate higher comprehension, but the data cannot establish whether particular combinations are more productive than others. Future research could compare pathways such as text–video, video–infographic, video–forum, or text–video–forum combinations. Multimodal learning analytics could be particularly useful for identifying sequences of engagement and their relationship with learning outcomes, building on recent work that examines behavioral and interactional patterns in online learning environments (Wang et al., 2023).

A third direction concerns the quality rather than frequency of interaction. The present study shows that students participated actively in forums, but the number of posts and replies cannot fully capture the cognitive quality of those contributions. Recent research has demonstrated the value of examining explanation, collaboration, cognitive engagement, and knowledge construction within discussion data (Burke et al., 2025; Rivera et al., 2025). Future studies could therefore combine forum analytics with discourse analysis to examine clarification, elaboration, disagreement, justification, and negotiation of meaning.

A fourth direction involves comparative research across linguistic and cultural contexts. Multimodal meaning-making is shaped by learners' linguistic repertoires, digital literacy, cultural expectations, and familiarity with different communicative modes. Research on digital multimodal composing in L2 education increasingly emphasizes learner agency, multimodal literacy, and contextual affordances (Jiang & Hafner, 2024; Zhang et al., 2024). Comparative studies involving students from different institutions or linguistic backgrounds could therefore establish whether the patterns identified here are context-specific or more widely applicable.

CONCLUSION

This study concludes that multimodal semiotic resources—including slides, videos, infographics, podcasts, and discussion forums are closely associated with students' meaning-making and comprehension in online applied linguistics learning. The findings indicate that students who engaged with multiple complementary modalities demonstrated higher levels of comprehension, while discussion forums provided an important space for reflection, peer interaction, and collaborative knowledge construction. The study also highlights the complementary pedagogical functions of different modalities, in which visual resources support clarity and organization, videos provide contextualized and multimodal explanations, podcasts facilitate listening-based engagement, and discussion forums encourage knowledge negotiation and collaborative learning. These findings suggest that effective online applied linguistics environments should not rely on a single mode of representation but should strategically integrate diverse resources while providing sufficient guidance and opportunities for learner interaction. In this respect, multimodal learning can be understood as an important component of meaning-making in digital education, particularly when students actively select, connect, and interpret resources according to their learning needs.

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