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Metacognitive scaffolding for foreign language fluency: Algorithmic and integrated learning schemes

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Abstract: This article explores the role of metacognitive scaffolding in developing foreign language fluency through the use of algorithmic and integrated learning schemes. Drawing on psycholinguistic and cognitive research, the study presents a theoretical foundation for employing metacognitive models—such as concept maps, discourse structures, and integrated mental schemes—in language instruction. These schemes facilitate learners’ ability to organize, monitor, and regulate their language learning processes. The approach is grounded in the principles of recursion, Content and Language Integrated Learning (CLIL) methodology, and simulation-based learning and is supported by recent developments in metacognitive theory and educational psychology. The article argues that such scaffolding not only enhances linguistic competence but also cultivates deeper cognitive engagement, self-regulation, and fluency. Examples of implementation are provided to illustrate how metacognitive tools can be integrated into foreign language classrooms for meaningful and systematic learning.

Keywords: metacognition; foreign language fluency; metacognitive scaffolding; concept maps; algorithmic learning; integrated learning schemes; CLIL; cognitive development; recursive learning; educational psychology

1. Introduction

The rapidly changing landscape of the digital age, marked by ubiquitous information technologies and pervasive AI integration, continues to reshape the cognitive and linguistic behavior of the Internet Generation. While young learners demonstrate an increasing aptitude for personalization, multitasking, and the development of soft skills, their cognitive habits are progressively characterized by fragmented attention, superficial analysis, and the frequent use of simplified language structures. These tendencies are particularly evident in foreign language learning, where learners often display minimal engagement with complex linguistic forms or conceptual structures. This cognitive and communicative shift presents a growing challenge for educators: how to balance the demands of an accelerated, digitalized environment with the pedagogical necessity for deep, structured, and meaningful engagement in second language acquisition.

In response to these challenges, global educational discourse has emphasized the urgent need for holistic, system-based models of language instruction that go beyond rote memorization or narrow skill development. Instead, a multidimensional perception of language learning is advocated—one that integrates cognitive, linguistic, and communicative dimensions. Within this pedagogical framework, metacognitive activity—the learner’s capacity to plan, monitor, and regulate their cognitive and linguistic actions—emerges as a foundational construct. Originating in the seminal

work of John Flavell [1] and further expanded by scholars such as Borkowski [2], Nelson and Narens [3], metacognition is increasingly recognized as an essential mechanism that supports intentional learning through goal-setting, mental regulation, and critical self-reflection.

When applied to foreign language education, metacognitive scaffolding fosters learners' conscious engagement with grammar, vocabulary, and discourse structures, thereby enhancing both receptive and productive language use. It facilitates the internalization of grammatical and semantic patterns, strengthens reflective control over decoding and encoding processes, and enables learners to orchestrate various cognitive operations required for coherent, purposeful communication. In this way, metacognitive strategies serve to reconcile the immediacy of digital fluency with the depth and complexity of academic language learning.

This study explores the role of algorithmic and integrated mental schemes—including visual organizers such as concept maps, genre-specific scaffolds, and discourse flowcharts—within a metacognitive framework of foreign language instruction. These tools were implemented as part of the Integrated Literacy Development Approach (ILDA) at a Ukrainian-English bilingual school, “Interclass,” with students in Grades 3–4 and Grade 9 serving as the primary research participants. The aim was to investigate how the application of metacognitive and visual-cognitive schemes enhances students' foreign language fluency, conceptual accuracy, and ability to engage in structured academic discourse in English.

Through the collection and analysis of learner-produced texts, classroom tasks, and observed interactions, the study identifies shifts in the use of polymodal discourse markers, cognitive operation vocabulary, and genre awareness in learners' speech and writing. By foregrounding the metacognitive dimension of foreign language pedagogy, the research contributes to ongoing efforts to design cognitively rich, linguistically meaningful, and developmentally responsive language learning environments.

1.1. Literature review and theoretical derivation

The integration of metacognitive scaffolding into foreign language education reflects a broader shift toward learner-centered pedagogies that emphasize cognitive engagement and strategic autonomy. This pedagogical turn is grounded in metacognitive theory, initially conceptualized by Flavell as the awareness and regulation of one's own thinking processes [1]. Expanding on this, Borkowski and colleagues proposed a process-oriented model that links metacognitive control to motivation and executive functioning, particularly in contexts requiring complex problem-solving [2].

Within the domain of second language acquisition (SLA), the role of metacognitive strategy use has been systematized in models such as Oxford's Strategic Self-Regulation (S2R) Model, which delineates metacognitive, cognitive, and socio-affective strategies as central to effective language learning [3]. In contrast to this strategy-based approach, the Integrated Literacy Development Approach (ILDA) offers a structural innovation: the use of metacognitive schemes—visual and

algorithmic templates—that scaffold language development by organizing content into conceptually meaningful modules.

Vygotsky’s theory of the Zone of Proximal Development (ZPD) provides another relevant framework, positing that learning occurs most effectively when guided by more knowledgeable others. ILDA expands on this by promoting the internalization of such guidance through structured recursive schemes that enable independent knowledge construction, bridging external support and cognitive autonomy [4].

Further alignment is found with Swain’s Output Hypothesis, which argues that language production fosters deeper learning through processes of noticing, hypothesis testing, and metalinguistic reflection. ILDA supports this output-focused model by embedding discourse mapping and genre-based production tasks that internalize language through structured repetition and recursive patterns [5].

Ukrainian psycholinguistic research has also contributed to the theoretical foundation of ILDA. Tokareva [6] and Vatan [7] emphasize the systemic and dynamic nature of cognitive processes in language learning. Tokareva and Tsehelska further advance this work by introducing metacognitive schemes as tools for representing knowledge in visual, recursive formats—using features such as conceptual fields, color coding, and hierarchical branching [8]. These schemes promote deeper cognitive engagement by facilitating mental modeling and reflective language use.

The intellectual basis for recursive scaffolding within ILDA is drawn from Anisimov’s theory of recursion, which conceptualizes learning as a layered, cyclical process of pattern recognition and creative synthesis [9]. This recursive logic aligns with emerging perspectives in educational neuroscience and cognitive psychology that stress the importance of feedback loops in developing metacognitive awareness and fluency [10,11].

In practice, ILDA integrates these theoretical strands through cognitively enriched instruction supported by simulation-based learning [12], Content and Language Integrated Learning (CLIL) frameworks [13], and innovative approaches like AI-supported instruction [14]. These methods provide learners with authentic, purpose-driven contexts for language use, promoting the transfer of knowledge across genres and communicative situations. As Tsehelska notes, genre-based strategies and discourse modeling allow learners to internalize linguistic structures in a meaningful and flexible manner [15].

By synthesizing findings from metacognitive theory, SLA, psycholinguistics, and educational psychology, this study positions ILDA as a comprehensive model of metacognitive scaffolding that enhances language learning through structured visualization, recursive logic, and reflective practice.

1.2. Sample

The study utilized a quasi-experimental design with two groups of learners participating in foreign language instruction within structured educational environments. A control group was not used; instead, a baseline comparison was established using pre-intervention language proficiency assessments to gauge initial competence.

The intervention lasted for one academic year, with a consistent dosage of exposure through 4–5 English-integrated lessons per week, each lasting approximately 40 min. The intervention focused on embedding metacognitive scaffolding through the Integrated Literacy Development Approach (ILDA), integrating visual and algorithmic schemes across subjects.

The first group consisted of 48 primary school pupils (Grades 3–4) attending a Ukrainian-English bilingual school, Interclass. These learners had varied linguistic backgrounds, predominantly Ukrainian-speaking, with English as a foreign language. Their prior English proficiency ranged from A1 to A2. This group was regularly exposed to both academic and communicative English through interdisciplinary subjects such as “I Explore the World,” mathematics, and arts and crafts. English instruction incorporated metacognitive tools, including concept maps, visual scaffolds, and mental schemes developed in alignment with ILDA.

The second group included 36 Grade 9 students from the same bilingual school, Interclass. These learners had more advanced English proficiency (B1–B2) and were also primarily Ukrainian speakers. Instruction for this group emphasized the application of integrated mental schemes and genre-based tasks to foster academic literacy. The pedagogical approach focused on using concept maps, cognitive scaffolds, and metalinguistic reflection to enhance vocabulary acquisition, genre awareness, and conceptual understanding across different academic subjects.

Both groups participated in ILDA-informed lessons designed to develop language fluency through recursive learning and metacognitive strategies. The tasks emphasized algorithmic reasoning, self-regulation, reflective thinking, and collaborative meaning-making, aiming to support both linguistic and cognitive development.

Data collection involved learner discourse samples, written reflections, structured classroom observations, and pre- and post-intervention language assessments. This approach provided a comprehensive analysis of how algorithmic and integrated mental schemes facilitated language fluency and cognitive engagement across developmental stages.

1.3. Research methods and techniques

The present study employed a qualitative-interpretative design supplemented by elements of action research, as the researcher was directly involved in the planning and implementation of pedagogical interventions in both primary and tertiary educational contexts. The study aimed to explore the impact of algorithmic and integrated metacognitive schemes on learners’ language fluency and cognitive development through the lens of systemic-functional and psycholinguistic theories.

The following research methods and techniques were applied:

- Observation and descriptive analysis were used to monitor and document learners’ behaviors, responses, and interaction patterns during tasks involving mental schemes. Structured observation protocols focused on indicators of metacognitive activity, including planning, monitoring, and evaluating learning actions.

- Discourse analysis was carried out on learners' oral and written language production. The analysis focused on the use of syntagmatic constructions, logical-semantic relations, and transformations within sentences and short texts to evaluate the learners' ability to transfer conceptual scaffolds into communicative acts.
- Student self-reflection protocols and learning diaries were used to capture learners' awareness of their thinking processes. These introspective tools provided insight into metacognitive growth and learners' perceived effectiveness of mental scheme use.
- Task-based performance analysis included algorithmic exercises, concept-mapping tasks, and storytelling activities. These tasks were designed to evaluate the extent to which learners internalized conceptual structures and applied them in linguistically meaningful ways.
- Comparative analysis was used to contrast the outcomes of students exposed to metacognitive scaffolding with baseline levels of discourse production prior to the intervention. Pre- and post-task samples were analyzed qualitatively to identify gains in language fluency, logical coherence, and genre awareness.
- Expert evaluation was employed in the higher education setting, where university students' application of metacognitive schemes in microteaching sessions was assessed using rubrics based on clarity, coherence, and scaffolded support of learners' language output.

This multi-method approach enabled a rich triangulation of data sources, ensuring both contextual sensitivity and depth of insight into the effects of metacognitive scaffolding on foreign language fluency.

1.4. Parameters for evaluating success

To assess the effectiveness of the program, the study identified representative markers of success in foreign language and subject learning among primary and tertiary-level learners engaged in metacognitive and algorithmic tasks. These parameters were selected based on key indicators of academic literacy, cognitive transfer, and fluency development and were categorized as follows:

- 1) Linguistic fluency and accuracy
 - Increased length and complexity of oral and written discourse
 - Correct use of grammatical structures and syntax within genres
 - Expanded thematic vocabulary appropriate to subject-specific contexts
- 2) Cognitive-coherence of discourse
 - Logical progression of ideas, including cause-effect, comparison, classification, and generalization
 - Use of cohesive devices and discourse markers to structure thoughts
 - Clarity in sentence-to-sentence transitions and paragraph organization
- 3) Genre awareness and adaptability
 - Ability to identify and reproduce key structural components of academic genres (e.g., descriptions, explanations, reports, narratives)
 - Appropriate language use for various communicative purposes
 - Flexibility in transforming conceptual content into different genres

- 4) Metacognitive awareness
 - Evidence of learners planning, monitoring, and evaluating their own learning
 - Use of mental schemes and concept maps to organize and guide speech and writing
 - Student reflections indicating awareness of strategy use and learning progress
- 5) Cross-disciplinary language transfer
 - Application of linguistic and conceptual tools across different subjects (e.g., using classification schemes in science or comparisons in social studies)
 - Integration of content knowledge and language use in task-based projects
- 6) Learner autonomy and motivation
 - Increased initiative in constructing learning materials and solving communicative tasks
 - Positive learner attitudes toward language learning and use of strategies
 - Participation in peer scaffolding, group tasks, and reflective discussions
- 7) Teacher observations and expert evaluation
 - Improved classroom performance based on observation rubrics
 - Enhanced teacher feedback on learners' ability to internalize and transfer metacognitive schemes
 - Ratings by external evaluators during demonstration lessons and academic presentations

Together, these indicators formed a holistic framework to monitor learner progress, identify areas for pedagogical improvement, and validate the potential of metacognitive scaffolding in fostering sustained language fluency and conceptual understanding.

2. Results

The implementation of algorithmic and integrated learning schemes through metacognitive scaffolding demonstrated a measurable positive impact on the development of foreign language fluency, genre competence, and content integration across primary and tertiary learners. Data collected from classroom observations, learner outputs, reflective feedback, and evaluation rubrics revealed several notable trends.

First, students exhibited increased fluency and genre control in oral and written tasks. Learners in both primary and university settings produced more coherent and extended utterances, using vocabulary and syntactic structures aligned with target genres. The integration of mental maps into lesson design provided a stable cognitive frame, helping students structure ideas logically and with growing independence.

Second, the use of metacognitive schemes resulted in enhanced conceptual clarity. Students were better able to classify, describe, compare, and evaluate objects, processes, and abstract concepts. Their ability to identify communicative purposes and apply appropriate linguistic means within those contexts grew substantially, especially when supported by visual scaffolding.

Third, learners demonstrated improved cross-disciplinary transfer of skills and vocabulary. Primary-level students began applying science-related structures (e.g., “Plants grow in...”, and “Animals live in...”) in both Ukrainian and English contexts, while older students adapted metacognitive tools such as Bloom’s Taxonomy and genre-based thinking to the analysis of texts and the design of academic assignments.

Fourth, learner autonomy and reflective awareness increased. Students across age groups reported greater confidence in managing their learning tasks, with many referencing the maps and schemes as helpful tools in understanding the structure of both the content and the language. Teachers observed a higher level of motivation and more active participation in peer discussions, especially when maps were used for planning and evaluating performance.

Finally, teachers found the algorithmic structure of the maps effective for lesson planning and differentiation. The visual logic of the schemes allowed for easy adaptation to different topics and learner needs, making it possible to scaffold tasks for various proficiency levels without losing coherence or purpose.

The following section details the specific maps developed and applied during the study, illustrating how these cognitive tools supported learning in foreign language instruction and across subject areas.

Figure 1 illustrates a metacognitive schematic tool, commonly referred to as a “grammar ruler,” which functions as an elementary symbolic system (pictogram) designed to support the construction of syntactic structures in a foreign language. Each graphic element represents a specific grammatical category: the diamond denotes an adjective, the oval signifies a noun (subject of the sentence), the arrow indicates the verb (predicate), the square corresponds to a noun (object), and the parallelogram represents an adverb.

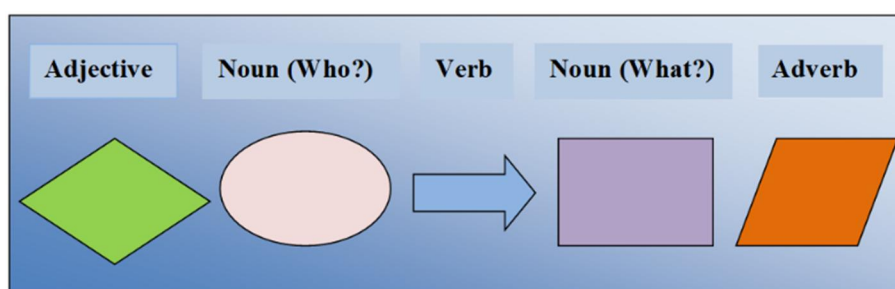


Figure 1. An example of an elementary “grammar ruler/line”—A scheme for logical-semantic structuring of sentences.

These visual representations facilitate the logical and semantic organization of sentence components, thus providing learners with a structured and accessible model for sentence formation. By integrating such visual grammar scaffolds, learners are able to internalize fundamental syntactic patterns and enhance their capacity to produce grammatically accurate and contextually appropriate utterances.

In the context of the Integrated Literacy Development Approach (ILDA), the use of grammar rulers supports the development of both linguistic competence and metalinguistic awareness. These schematic tools are particularly effective in bilingual and multilingual learning environments, where they serve as cognitive anchors bridging the learner’s first language (L1) with the target language (L2). Consequently,

they contribute significantly to learners’ acquisition of academic literacy and their ability to engage in meaningful communication across languages.

The next figure presents a metacognitive scheme of a conceptual type, which plays a crucial role in the process of meaning formation and cognitive construction during English language acquisition. This type of visual tool facilitates the development of students’ conceptual understanding by organizing and illustrating the relationships among identified objects and categories within a targeted conceptual domain—in this case, the semantic field of “food.”

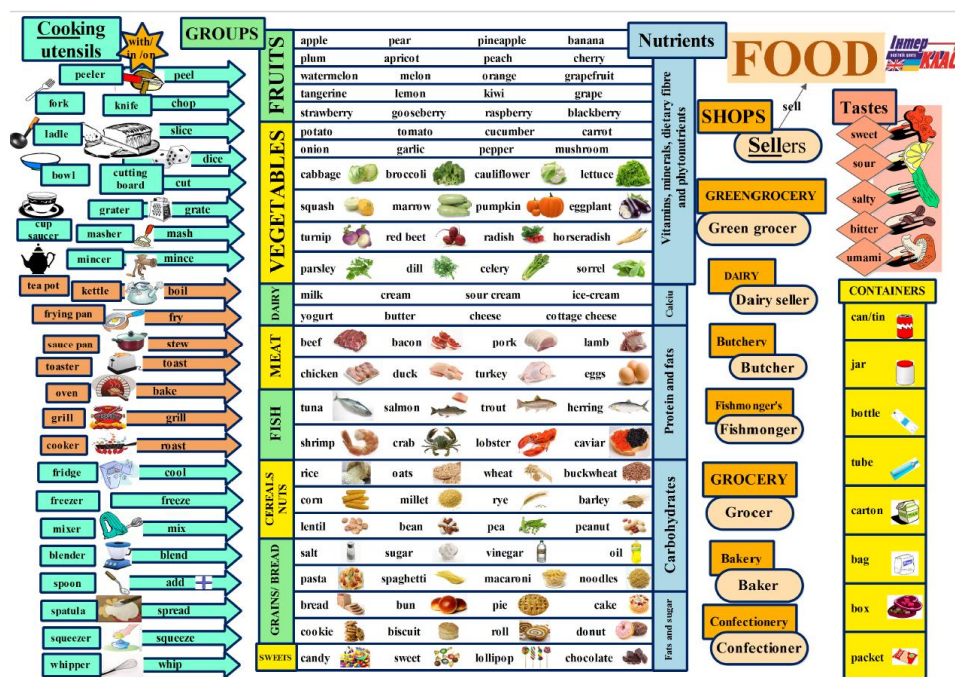


Figure 2. Conceptual-type metacognitive scheme for representing the semantic field of ‘food’.

Through the generalization and systematization of symbolic information, this schematic representation enables learners to build a mental denotative graph—a structured mental map—within their linguistic consciousness. Such mapping supports learners in recognizing and internalizing grammatical and logical connections between concepts, contributing to their overall understanding of language structure and use.

The scheme in **Figure 2** categorizes vocabulary into thematic clusters, including food groups (fruits, vegetables, meat, dairy, fish, cereals, sweets, grains), nutritional content (vitamins, carbohydrates, proteins), utensils and cooking methods, places and sellers, containers, and taste descriptors. It thus integrates linguistic, cognitive, and cultural components, fostering lexical awareness, semantic integration, and cross-categorical reasoning.

In the context of the Integrated Literacy Development Approach (ILDA), such schemes serve as powerful scaffolding tools, guiding learners from vocabulary recognition to conceptual analysis and productive use in communication. They promote not only vocabulary expansion but also the development of interdisciplinary thinking by connecting language learning with science (e.g., nutrients), culture (e.g., food types and customs), and everyday experiences.

The visual in **Figure 3** exemplifies an algorithmic-type metacognitive scheme designed to support learners in mastering more complex tasks in English language acquisition. Unlike static concept maps, this type of scheme reflects the systemic content of an individual’s metacognitive experience, incorporating structured algorithmic logic that ranges from basic directional and branching structures to more advanced templates and syntactic patterns.

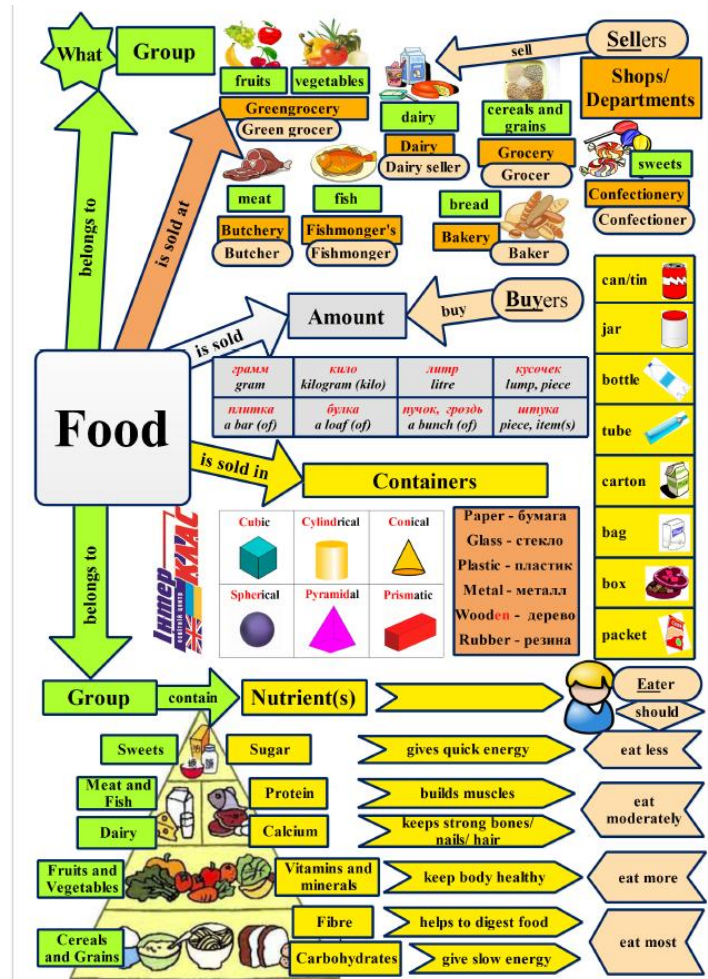


Figure 3. Algorithmic-type metacognitive scheme for structuring the conceptual domain of ‘food’.

These algorithmic schemes facilitate the conscious and effective structuring of information, enabling learners to recognize logical dependencies and to align elements within multi-level mental denotative graphs. Such alignment supports the recursive expansion of conceptual domains (conceptospheres) in second language learning, particularly within the framework of linguistic recursion.

The schematic representation of “Food” (**Figure 3**) integrates visual elements, symbolic notation, and differentiated color coding to represent functional relationships among food categories, utensils, containers, tastes, and nutrient types. Through this multimodal design, learners engage not only in semantic categorization but also in syntactic modeling, as the scheme implicitly guides the construction of language patterns and sentence structures (e.g., “We cut fruit with a knife,” “Milk comes in a bottle”).

By operationalizing these algorithmic schemes, learners internalize the logical models of second language syntax and lexicon. These visual tools thereby function as scaffolds for cognitive automation, supporting the transition from conscious language processing to fluent language production. Within pedagogical frameworks such as the Integrated Literacy Development Approach (ILDA), algorithmic-type schemes play a critical role in shaping both metalinguistic awareness and productive language competence.

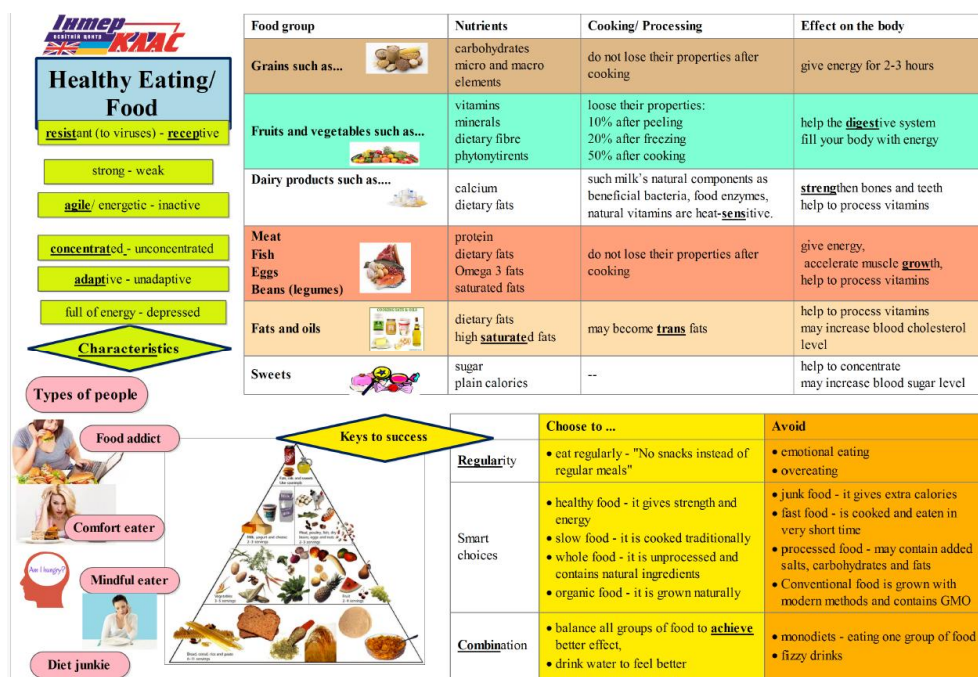


Figure 4. Integrated mental scheme (mind map) for the thematic module “healthy eating”.

The most complex form of metacognitive learning schemes is represented by integrated mental schemes, or intellect maps, which serve as dynamic tools for conceptual generalization and multidimensional language development. As shown in Figure 4, the mind map “Healthy Eating” exemplifies a holistic metacognitive model that consolidates various lexical fields—such as food groups, nutrients, cooking processes, and consumption contexts—into an interconnected modular structure. This integration enables learners to navigate and produce extended discourse in the foreign language across a polyvector continuum of syntagmatic formations.

The construction of such a mental scheme can be scaffolded by recursive-projectional content derived from simpler conceptual and algorithmic metacognitive schemes (Figures 2 and 3). The mind map thus synthesizes these foundational formats into a higher-order cognitive model designed for complex language production and comprehension.

The processing of this integrated scheme can be approached along multiple cognitive vectors:

- 1) Vertically, the “Healthy Eating” mind map supports the systematic development of metacognitive processes related to perception, classification, and internalization of key concepts such as food categories, nutritional value, dietary

balance, and health outcomes. Learners engage with overarching themes (e.g., vitamins, carbohydrates, proteins) and related sub-concepts (e.g., fruit and vegetables, sugar intake, fiber) to build semantic hierarchies and reinforce conceptual clarity.

- 2) Horizontally, the scheme guides learners through the syntactic modeling of extended utterances. It visually represents the sequencing and rephrasing of sentences, ordering of syntagmatic structures, and establishment of logical-semantic connections between elements. Through this, learners acquire practical strategies for sentence construction, thematic cohesion, and lexical variation, all within the framework of a communicatively relevant domain.

In educational settings guided by the Integrated Literacy Development Approach (ILDA), an experiment was conducted to examine how the use of integrated mental schemes—such as concept maps and genre-based visual organizers—supports students in demonstrating and expanding their vocabulary knowledge. The core objective was to determine whether cognitively structured scaffolding tools could facilitate more fluent, conceptually accurate, and contextually transferable language use.

During the experiment, students engaged in a series of learning tasks that required them to visualize academic vocabulary and thematic content through algorithmically guided concept maps. These maps, designed around key vocabulary and genre structures, enabled learners to organize and retrieve words and ideas more effectively. Students were then asked to use the visualized material in oral and written tasks, allowing researchers to assess the frequency and quality of polymodal markers in their language production.

Table 1. Generalized results of quantitative indicators of polymodal marker usage in learner output.

Category of Polymodal Marker	Examples from Learner Output	Before Intervention (Mean per 50 words)	After Intervention (Mean per 50 words)	% Change	p-value	Cohen's d
Thinking Operation Language	group, compare, describe, rate, explain	2.5	7.4	+196%	< 0.05	0.9
Genre-Structuring Markers	First, then, because, in conclusion, finally	3.1	8.6	+177%	< 0.05	0.8
Metacognitive Verbs	I know, I think, I guess, I understand, I'm not sure	1.8	6.3	+250%	< 0.05	1.0
Cross-modal Integration Markers	According to the scheme, as seen in my map, this picture shows	0.7	4.1	+486%	< 0.05	1.2

The results of this experimental intervention clearly indicate a marked improvement in learners' use of polymodal markers, a linguistic indicator of vocabulary application and discourse fluency. These markers are closely linked to the visualization activities and genre modeling tasks carried out using the ILDA-based conceptual schemes (**Table 1**).

The most significant gain was recorded in the use of cross-modal integration markers (+486%), demonstrating that learners became more skilled and confident in referencing visual tools—such as maps and schemes—during verbal and written expression. The notable rise in metacognitive verbs (+250%) suggests heightened

learner awareness of their own thinking and language processing strategies. Increases in thinking operation language (+196%) and genre-structuring markers (+177%) further affirm that the structured integration of vocabulary and conceptual frameworks leads to purposeful and academically aligned language use.

This experiment provides compelling evidence for the pedagogical value of visual metacognitive scaffolding in vocabulary learning and broader foreign language literacy development.

Interpretation of the statistical results

The statistical analysis of the pre- and post-intervention data reveals substantial gains in learners' use of polymodal markers, which indicate an enhancement in cognitively and linguistically enriched discourse. The increase in the frequency of polymodal markers across all four categories—thinking operation language, genre-structuring markers, metacognitive verbs, and cross-modal integration markers—demonstrates the effectiveness of the Integrated Literacy Development Approach (ILDA) in fostering deeper language acquisition.

To assess the significance of these changes, paired sample t-tests were conducted for each category of polymodal marker. The results indicated statistically significant improvements ($p < 0.05$) in all four categories. Additionally, effect sizes (Cohen's d) ranged from 0.8 to 1.2, indicating large effects, with the most substantial impact observed in the use of cross-modal integration markers ($d = 1.2$).

The increase of +486% in cross-modal integration markers suggests that learners became significantly more adept at verbally referencing and integrating visual tools such as concept maps, genre frames, and schematic diagrams into their speech and writing. This result highlights a successful internalization of visual scaffolds as cognitive aids, fostering metalinguistic awareness and multimodal expression.

Similarly, the use of metacognitive verbs increased by +250%, reflecting a marked development in learners' ability to articulate and regulate their thinking processes. Expressions like "I think," "I understand," and "I'm not sure" indicate an emerging ability to engage in reflective and self-directed learning, which are key components of language autonomy.

The observed increase in thinking operation language by +196% indicates that learners are progressively internalizing academic discourse patterns essential for analytical thinking. Terms such as group, compare, describe, and rate became more prevalent, signifying an enhanced ability to perform complex cognitive tasks within language learning.

Finally, the +177% rise in genre-structuring markers indicates improved textual coherence and organizational skills, allowing learners to produce more structured narratives and explanations. The increased use of sequencing phrases like "First," "Then," "Because," and "In conclusion" supports the development of both written and oral academic communication.

While the results are promising, it is important to acknowledge that inferential statistical analysis was applied to a relatively small sample size, which may affect the generalizability of the findings. Future research could include larger and more diverse cohorts to validate these outcomes. Nevertheless, the substantial effect sizes observed

provide strong evidence for the pedagogical value of ILDA in enhancing metacognitive and linguistic competencies in foreign language learners.

3. Implications for foreign language pedagogy

The findings of this study offer compelling implications for foreign language pedagogy, particularly within contexts where language is learned not as an isolated system but as a vehicle for knowledge construction. The integration of metacognitive scaffolding—through concept maps, algorithmic schemes, and genre-based learning—marks a paradigm shift from form-focused instruction to meaning-oriented, cognitively enriched language development.

(a) From input to output-oriented learning

One key implication is the shift toward output-oriented instruction, where learners are encouraged to generate texts, reflect on structure, and engage with the purpose and logic of genres. This fosters not only linguistic accuracy but also fluency and functional language use. Teachers are urged to facilitate productive skills through structured thinking, rather than relying solely on comprehension tasks or mechanical drills.

(b) Genre awareness as a pathway to academic literacy

Incorporating genre-based metacognitive maps trains students to recognize the communicative purpose, structure, and linguistic features of texts. Such awareness helps learners transfer skills across subjects, making foreign language use more academic and contextually appropriate. This is particularly important in CLIL and EMI environments, where students need to express abstract thinking in English across curriculum areas.

(c) Metacognitive tools for learner autonomy

The approach supports learner autonomy and self-regulation. By using cognitive verbs, text organizers, and recursive genre schemes, students begin to internalize strategies for planning, monitoring, and evaluating their language use. Teachers can encourage students to verbalize their thought processes, which contributes to conscious language learning and increased metacognitive control.

(d) Differentiation and inclusive practice

Because metacognitive scaffolding is visual, modular, and recursive, it naturally lends itself to differentiation. Learners at varying levels of linguistic development can access the same cognitive content through tailored language support. The visual and logical structure helps scaffold for learners with special educational needs, emergent bilinguals, and those with low confidence in language production.

(e) Teacher and learner perspectives

Given that metacognitive scaffolding is inherently learner-centered, it is crucial to incorporate qualitative data reflecting learners' voices. Including excerpts from student reflections or narrative examples of growth would enrich the narrative, highlighting how ILDA tools impact learning from the learners' perspective. Furthermore, documenting teachers' experiences, challenges, and perceptions when implementing these tools would provide a more nuanced understanding of practical application and professional development needs.

(f) Teacher professional development

Finally, the results underscore the need for teacher training in metacognitive and genre-based approaches. Teachers must be equipped not only with language teaching techniques but also with an understanding of how to foster thinking through language. This calls for interdisciplinary collaboration between subject teachers, language educators, and curriculum designers.

4. Conclusions

The present study investigated the impact of metacognitive scaffolding—implemented through algorithmic and integrated learning schemes—on foreign language fluency and content-based literacy development. Drawing on a robust theoretical framework rooted in cognitive and metacognitive psychology, systemic functional linguistics, and CLIL methodology, the research provided empirical evidence that such scaffolding enhances learners' ability to construct meaningful, coherent discourse in a foreign language, particularly in educational settings that demand simultaneous acquisition of language and subject content.

The data collected from classroom implementation across various stages of the program demonstrated a progressive and measurable improvement in learners' oral and written production. These gains were especially evident in the increased use of polymodal discourse markers, enhanced control over logical-semantic relations, and the ability to structure discourse according to genre-specific conventions. These findings suggest that the recursive use of algorithmic support tools—such as conceptual maps, metacognitive schemes, and text modeling—facilitates the internalization of both language structures and cognitive operations, fostering deeper engagement with the target language as a medium of thought, not merely communication.

The success of the program underscores the relevance of metacognitive awareness in language learning. When learners are explicitly guided to reflect on their thinking processes, identify patterns in text organization, and map their ideas according to purposeful genre logic, they are more likely to become autonomous, strategic language users. This metacognitive orientation aligns well with contemporary educational paradigms that emphasize lifelong learning, critical thinking, and transdisciplinary knowledge construction.

Moreover, the study confirms the pedagogical value of integrating genre-based and cognitively structured approaches into foreign language education. It advances the argument that meaningful language acquisition requires more than lexical or grammatical input; it necessitates the systematic organization of discourse around conceptual, functional, and contextual knowledge. In this sense, the developed approach contributes to both the theory and practice of bilingual and multilingual education.

Adapting the model to diverse educational contexts:

While the study was conducted within a Ukrainian-English bilingual school context, it is crucial to consider the adaptability of the model in different educational settings. In multilingual immigrant schools, where learners come from varied linguistic and cultural backgrounds, the model may require additional contextualization to accommodate diverse language proficiencies and cultural

perspectives. Similarly, in low-resource environments or adult education contexts, the visual and conceptual nature of ILDA could be streamlined to focus on core scaffolding techniques that do not rely heavily on technological resources. Future research should explore these adaptations to maximize the model's inclusivity and applicability.

Inclusion and accessibility considerations:

The visual, modular, and recursive nature of metacognitive scaffolding inherently supports differentiation. However, it is essential to explicitly address the needs of learners with special educational needs and emergent bilinguals. Tailoring the cognitive complexity of the scaffolding tasks and incorporating multimodal input can make the approach more accessible. Teachers should also be trained to recognize and accommodate diverse learning profiles, ensuring that ILDA tools promote equitable access to language learning.

Conclusions:

- 1) **Metacognitive scaffolding fosters fluency and coherence:** Structured thinking tools significantly support learners in organizing their speech and writing around meaningful communicative tasks.
- 2) **Algorithmic and integrated learning schemes facilitate cross-disciplinary competence:** By linking language learning with subject content and cognitive development, learners demonstrate improved academic literacy.
- 3) **Genre modeling enhances discourse control:** Students become capable of constructing texts aligned with genre expectations, improving both form and function in language use.
- 4) **Polymodal markers serve as valid indicators of linguistic and cognitive growth:** Their increasing use reflects learners' expanding repertoire for managing information, stance, and coherence.
- 5) **Cultural adaptability and inclusion are crucial for broader implementation:** Future studies should investigate how the ILDA model can be tailored for multilingual, low-resource, and adult education environments while maintaining accessibility for learners with diverse needs.

This study contributes to a growing body of research advocating for cognitively enriched, genre-oriented language pedagogy. Future studies should continue to explore the longitudinal impact of such approaches, the potential for digital and AI-supported scaffolding, and the adaptability of the model across diverse linguistic and educational contexts.

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