

Using a digital visual dictionary to support reading comprehension: A single-case study with French-as-a-Second Language learners in primary school

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Abstract

GamesHub is an adaptive digital environment developed under the DOcTA2le-FR¹ research project to support reading-comprehension development in French as the Language of Instruction (FLens) within Swiss primary classrooms (ages 8–10) characterized by significant linguistic and cultural diversity. It features a Digital Visual Dictionary (VD)—offering phonetic and orthographic search, definitions, illustrations, and synonyms—and educational games targeting one category of the cognitive processes underpinning reading comprehension: integrative processes. Over the course of an academic year, we conducted two experimental phases, totalling 289 game sessions across 12 classes over nine months. Each pupil completed pre- and post-reading-comprehension tests at the start and end of each phase, allowing us to measure their comprehension levels before and after gameplay. For this paper, we conducted a single-case study focusing on four pupils for whom FLens is not their first language. We scored and tracked changes in their comprehension-test results, then analysed their digital traces—both their game scores and the frequency of VD consultations, including the specific words looked up. Preliminary findings reveal links between individual VD usage, game-score evolution, and comprehension-test gains. Given the very small sample (four pupils) and the single-case design, these findings are exploratory and not generalizable. We therefore report a dedicated Limitations section and frame pedagogical implications as tentative within CALL practice. Nonetheless, this study demonstrates the value of combining quantitative and qualitative data to understand how an inclusive CALL tool may support reading-comprehension autonomy for French as a Second Language (FSL) learners in a primary FLens context.

Keywords: digital visual dictionary; reading comprehension; French as a Second Language; adaptive learning environment.

1. Introduction

In francophone Switzerland, primary classrooms are welcoming an increasing proportion of French as a Second Language (FSL) pupils whose mastery of French as the Language of Instruction (FLens) is crucial for academic success. These learners must not only acquire sufficient vocabulary but also develop strategies for text comprehension—a challenge heightened by the diversity of their home languages and cultural backgrounds.

Numerous studies have demonstrated the importance of lexical coverage for fluent, autonomous L2 reading. For instance, Ramnäs (2019) analyzed three French novels with first-semester university students in Sweden and concluded that knowledge of 7,000–9,000 lemmas is required to achieve 98 % text coverage, the threshold at which reading can proceed “without assistance” and in an enjoyable manner. Such a high lexical demand underscores the need, in FLens contexts, to embed tools that bolster active vocabulary acquisition and deployment. It is with this aim that we focus on the use of GamesHub’s Digital Visual Dictionary (VD)—not in comparison to a control group, but through an interpretive scientific stance that examines, for pupils whose first language is not French, their VD usage and lookup patterns, the evolution of their game scores, and, ultimately, changes in their reading-comprehension test performance.

Within this framework, Technology-Enhanced Learning (TEL) and, more specifically, Computer-Assisted Language Learning (CALL) offer resources capable of simultaneously supporting vocabulary growth and textual meaning-making. In CALL research, multimedia/visual glosses have been shown to facilitate reading comprehension and vocabulary learning, especially when embedded in task-oriented environments (Chun & Plass, 1996; Abraham, 2008; Wang, Liu, & Lee, 2023; Mahdi, 2024). Positioning our visual dictionary within this line of work, we pair fine-grained usage traces (lookups, retries) with construct-level outcomes to describe appropriation patterns rather than to infer causality from a small N.

We adopt an instrumental approach (Rabardel, 1995), which treats digital tools not as mere artefacts but as instruments shaped by learners’ evolving usage schemes—a process evidenced by the emergence of reproducible operational schemata (Vergnaud, 1985; Vergnaud & Récopé, 2000). GamesHub, the environment under study, provides a toolbox during gameplay that includes several Additional Features (AF): text-to-speech, dyslexia-friendly fonts, contrast adjustments, and the Digital Visual Dictionary (VD). The games themselves are designed to exercise integrative processes—the cognitive operations foundational to reading comprehension as defined by Irwin (2007) and adapted for francophone contexts by Giasson (2008), details of which follow in the Theoretical Framework section.

Situated within CALL, this study examines how a visual dictionary embedded in a TEL can support reading comprehension processes in primary FSL contexts. We complement existing work on multimodal scaffolds and learner autonomy by combining fine-grained usage traces (VD lookups and number of retries) with construct-level test outcomes. Our aim is descriptive: to characterise usage trajectories and their possible alignment with changes in performance, without inferring causality from a very small sample.

This paper forms part of doctoral research investigating how pupils instrumentalize such resources in service of their learning. Earlier work demonstrated that introducing a VD into a TEL generates operational invariants that facilitate meaning-making (Plessis-Ouzariah, 2025). The objectives of this paper are twofold: first, to describe the appropriation trajectories of the VD within educational games by four FSL pupils; second, to examine whether patterns emerge between these trajectories and gains in both game performance and reading-comprehension tests.

2. Theoretical framework

This section first situates GamesHub as a Technology-Enhanced Learning (TEL) within the Universal Design for Learning (UDL) framework, in order to make explicit the design choices (AF, adaptive pathways). It then specifies the reading-comprehension processes targeted by the games. We next discuss the role of visual dictionaries (VD) in supporting lexical access. Finally, we draw on the instrumental approach to analyze pupils’ appropriation of VD.

2.1. Universal design for learning

The Universal Design for Learning (UDL) aims to make instruction inclusive from the outset by engaging three neural networks: recognition (what), strategic (how), and affective (why) (CAST, 2025). It is operationalized through three principles: offering multiple means of representation (text, image, audio), multiple means of action and expression (varied interaction and production options), and multiple means of engagement (choices,

challenges, motivating feedback) (Rose & Meyer, 2002). The UDL Guidelines 2.2 detail how these principles can be concretely applied in primary education.

In GamesHub, UDL principles manifest as ‘representation’: All text can be displayed in a dyslexia-friendly font with adjustable contrast, and an interactive VD is available (phonetic/orthographic search, illustrations, definitions, synonyms) alongside text-to-speech. The goal is to diversify and ease access to written text and vocabulary for all learners; action and expression’: Pupils follow adaptive (personalized) game pathways designed to exercise integrative processes; and ‘engagement’: Immediate feedback on each activity and a rewards dashboard for correct answers stimulates motivation and autonomy.

These ergonomic and pedagogical choices aim to lower barriers to reading comprehension for all learners by encouraging reflective use of resources. However, while UDL seeks to reduce barriers through multiple means of representation, action/expression, and engagement, it does not imply uniform effectiveness for all learners or contexts. In multilingual primary settings, supports such as a visual dictionary may benefit profiles differently, and effects can be delayed or stabilizing rather than immediately performance-boosting. This assumption underpins our descriptive stance in the present study. In line with this, the UDL principles have guided the game design; we now specify the reading-comprehension processes these games are meant to exercise.

2.2. Processes of reading comprehension

According to Irwin (2007), the fundamental operations underlying comprehension can be divided into distinct levels: Microprocesses, which handle the interpretation of small text segments; Integrative processes, which connect separate pieces of information; Macroprocesses, which organize the overall structure and major ideas of the text; Elaborative processes, which involve linking the text to background knowledge beyond the passage itself; and Metacognitive processes, which encompass the reader’s self-monitoring and regulation during reading.

These mechanisms are engaged in reading any language, though each language may present unique characteristics. In the case of French, Giasson (2008) incorporates the use of morphosyntactic clues into the category of integrative processes. Such clues play a crucial role in French, since many grammatical markers are visible in writing yet not directly perceived in speech. Because these processes place a strong demand on lexical access, we next consider the contribution of visual dictionaries integrated into TELs.

2.3. Visual dictionaries

Visual dictionaries integrated into TEL thus represent an emerging research area, especially in primary education. To date, few studies have systematically examined their classroom use: in an early report on our experiment (Plessis-Ouzariah & Geoffre, 2025), we found that GamesHub’s VD was activated over 4,000 times across 150 sessions, despite the manual entry required. Initial qualitative analyses revealed two appropriation strategies: an *exploratory stance*, marked by broad experimentation with features (e.g., navigating among synonyms and illustrations), and a *functional stance*, focused on rapid keyword searches to resolve specific comprehension challenges. To analyse how VD becomes a genuine cognitive support, we finally draw on the instrumental approach.

2.4. Instrumental approach

Framed within CALL, we treat the VD as an instrument whose appropriation emerges from learners’ evolving schemes; our analysis focuses on how these schemes manifest in logs and how they align—exploratorily—with changes on reading constructs. The instrumental approach, as formalized by Rabardel (1995), clearly distinguishes the artefact—i.e., the object used—from the instrument, which comprises the set of usage schemes that the learner develops through appropriation. This instrumental genesis unfolds through two complementary processes: *instrumentation*, where the artefact, initially neutral, becomes the source of new action possibilities for the pupil; and *instrumentalization*, where the pupil adapts the artefact to his/her needs and constraints, thereby creating a

personalized instrument. In a primary-school context, these processes help explain how a digital tool such as a VD evolves from a mere resource into a genuine cognitive support for reading comprehension.

These findings converge on the idea that a VD, by combining multimodality and ease of access, can reduce the cognitive load of lexical search and directly support comprehension processes. In GamesHub, VD consultations serve as a bridge between gameplay and the resolution of comprehension blockages: by examining usage logs alongside gains measured on different constructs, our study aims to describe each pupil's usage trajectories in context. This leads us to the following research question: What trajectories of VD use, game scores in GamesHub and reading-comprehension test-score evolution emerge among FSL pupils?

3. Research method: participants, materials, and procedures

This is a single-case exploratory study focusing on four FSL pupils purposively selected to illustrate contrasting profiles. The protocol prioritizes rich process data over statistical inference. All findings should be interpreted as indicative and non-generalizable. Four FSL pupils (aged 8–10) in French-speaking Switzerland, with varied FLens exposure, were selected: Pupils 1 and 2: non-Romance L1; they began learning French upon school entry and use it primarily outside the home (friends and extracurricular activities); Pupil 3: Romance L1 (Portuguese); has spoken French since age three and uses it moderately with family; and Pupil 4: Romance L1 (Spanish); began French upon school entry and rarely uses it outside the classroom.

The reading-comprehension tests were designed accordingly. Three versions exist: the first, *Kodjo* (Poitou & Bera, 2019), and two others—*Fantine* and *Sheng* (Dherbey Chapuis & Berthele, 2021)—derived from it. Each digital test comprises a text and 24 questions, each assessing one of the five constructs defined by Dherbey Chapuis and Berthele based on Irwin's levels, with *Lexique* specified and metacognitive processes removed. The five constructs are: Lexique (vocabulary access and use); Microprocesses; Integration; Macroprocesses; and Elaboration

We employed a single-case design over two 10- and 12-week phases, with two 30-minute gameplay sessions per week. In Phase 1, we alternated activation and deactivation of the Additional Features (AF). Phase 2 followed the same protocol, introducing and then withdrawing Adaptive Learning (AL). Before Phase 1, all classes took one test version at random (T1) under a counterbalanced rotation; at the end of Phase 1 (T2), they took a second version. Before Phase 2 (T3), they took the third version; and at its conclusion (T4), they retook the first version. For each of the four FSL pupils, we extracted their scores from all four test administrations, their detailed game performance logs, and their VD usage traces (frequency of access per game and words queried).

4. Results and discussion

Across four primary FSL pupils in French-speaking Switzerland, two usage styles emerged—exploratory and measured—with trajectories shifting around AF/AL; construct-level changes were selective (not uniform), indicating profile-dependent, non-causal alignments between VD use, gameplay and test outcomes.

4.1. Pre-/post-tests by construct

Below are the results of all reading comprehension tests for each pupil, detailing their scores by construct and the gains observed.

Construct-level changes from T1 to T4 were selective rather than uniform. Pupil 1 shows a modest improvement on *Lexique* (+1/4) with stability elsewhere, for an overall +2/24. Pupil 2 is broadly stable with a slight decrease on *Integration* (−1/9) and 0/24 overall. Pupil 3 records a small +1/9 on *Integration* with no change on *Lexique*, for +1/24 overall. Pupil 4 shows clear gains on *Integration* (+4/9) and a small increase on *Lexique* (+1/4), for +4/24 overall. These patterns reinforce profile-dependent, non-causal alignments between tool use and outcomes within

a single-case (N=4) scope.

These profiles highlight the high variability of individual trajectories: although all four pupils make overall progress, the processes they engage in differ by profile. Some strengthen their *Integration* skills (precisely what the educational games target), while others consolidate vocabulary. This granularity underscores the importance of fine-grained monitoring by construct, and thus the need to examine in greater detail each pupil's game performance and VD usage.

4.2. Game trajectories by pupil

To complement the exploration of reading-comprehension test scores, we now examine, pupil by pupil, the evolution of their performance in GamesHub. The objective is to describe the shapes of their game trajectories and assess their coherence with the gains observed in the tests.

In summary, two pupils (3 and 2) exhibit an upward linear trend in their game scores, while the other two (1 and 4) show a downward or stable trend. For Pupil 3, the gameplay increase accompanies a modest gain of +1/9 on the *Integration* construct and +1/24 overall, whereas Pupil 2, despite improved game scores, shows no test gains (0/9 on *Integration*, 0/24 overall). Conversely, Pupil 1 experiences a decline in game performance but records +1/4 on *Lexique* and +2/24 overall with no change on *Integration*, and Pupil 4, whose slope is slightly negative, achieves +4/9 on *Integration*, +1/4 on *Lexique*, and +4/24 overall.

Regardless of profile, each transition in game conditions marks an inflection point: the introduction of AF generally coincides with a slowdown or slight dip in scores, and their withdrawal consistently induces a temporary trough. It is important to note that AF introduction does not always produce an immediate score increase; depending on a pupil's starting level, exercise complexity, and appropriation of the features, the effect may manifest gradually or serve chiefly to stabilize a performance plateau before a clearer rebound appears under AL or through repeated practice. Conversely, AL activation tends to trigger a rebound or rise in the LOWESS trend, and its removal leads to another dip or stabilization in a trough. These shifts are accompanied by variations in VD usage and retries, without any direct causal link to the gains measured in reading tests—prompting us to examine more closely when, where and how often pupils actually looked up.

4.3. Visual dictionary usage

In each of the three figures, each column corresponds to a game:

The bottom row indicates, for each column, the total number of exercises completed by all four pupils in that phase, and directly above, the “dico-img” cell shows the total number of VD consultations—again for all four pupils—followed in parentheses by the corresponding percentage. This percentage is always calculated by dividing the number of VD consultations by the total exercises for that game in the phase, then multiplying by one hundred. For example, in Phase 1, *Matching* (M) registers 31 consultations out of 84 exercises $(31 / 84) \times 100 \approx 36.9\%$ —and the 35 consultations across 333 exercises yield $(35 / 333) \times 100 \approx 10.5\%$.

When comparing the three phases, we observe that both in absolute terms (35 → 23 → 17 consultations) and proportionally (10.5 % → 5.5 % → 2.9 %), VD use by the four pupils steadily decreases despite the rising exercise volume (333 → 418 → 595). Matching remains the most VD-dependent in Phase 1 (36.9 %), PIOPL and Matching share the lead without AL (around 10 % each), whereas under AL QEP peaks at 15.4 %, followed by PIOPL at 10.6 %. Note that despite the overall downward trend, certain game contexts—particularly QEP under AL—see a punctuated increase in VD usage.

FA Type	DT	M	PIOPL	QEP	Tirettes	Total
dico-img	0 (0.0%)	31 (36.9%)	2 (2.4%)	1 (1.5%)	1 (3.0%)	35 (10.5%)
dyslexic	0 (0.0%)	1 (1.2%)	0 (0.0%)	3 (4.5%)	0 (0.0%)	4 (1.2%)
space	1 (3.2%)	1 (1.2%)	0 (0.0%)	7 (10.6%)	0 (0.0%)	9 (2.7%)
Total FA	1 (3.2%)	33 (39.3%)	2 (2.4%)	11 (16.7%)	1 (3.0%)	48 (14.4%)
Exercises	31	84	82	66	33	333

Figure 1. Number of AF uses by the four pupils during Phase 1

Upon AF activation, 3 and 1 explore the VD extensively, primarily for nouns and adjectives, whereas 2 performs only one verbal lookup and 4 none.

FA Type	DT	M	PDP	PIOPL	QEP	Total
dico-img	3 (5.3%)	3 (1.8%)	4 (1.7%)	7 (10.6%)	0 (0.0%)	17 (2.9%)
dyslexic	0 (0.0%)	0 (0.0%)	1 (0.4%)	4 (6.1%)	3 (5.8%)	8 (1.3%)
playTTS	0 (0.0%)	3 (1.8%)	2 (0.9%)	1 (1.5%)	4 (7.7%)	10 (1.7%)
space	0 (0.0%)	0 (0.0%)	2 (0.9%)	5 (7.6%)	1 (1.9%)	8 (1.3%)
Total FA	3 (5.3%)	6 (3.6%)	9 (3.8%)	17 (25.8%)	8 (15.4%)	43 (7.2%)
Exercises	57	169	235	66	52	595

Figure 2. Number of AF uses by the four pupils during Phase 2 without AL

Without AL, 3 renews a diversified use of the VD, while the other pupils limit themselves to one or two entries, reflecting a more targeted appropriation.

FA Type	Classes	DT	M	PDP	PIOPL	QEP	Total
dico-img	13 (144.4%)	1 (1.9%)	3 (3.4%)	1 (0.9%)	5 (8.3%)	0 (0.0%)	23 (5.5%)
dyslexic	0 (0.0%)	0 (0.0%)	2 (2.3%)	0 (0.0%)	0 (0.0%)	1 (1.8%)	3 (0.7%)
playTTS	0 (0.0%)	0 (0.0%)	2 (2.3%)	0 (0.0%)	1 (1.7%)	1 (1.8%)	4 (1.0%)
space	0 (0.0%)	0 (0.0%)	1 (1.1%)	0 (0.0%)	0 (0.0%)	1 (1.8%)	2 (0.5%)
Total FA	13 (144.4%)	1 (1.9%)	8 (9.2%)	1 (0.9%)	6 (10.0%)	3 (5.4%)	32 (7.7%)
Exercises	9	54	87	113	60	56	418

Figure 3. Number of AF uses by the four pupils during Phase 2 with AL

Under AL, 1 continues a varied and intensive exploration, 3 and 2 limit their consultations to 2–3 words, and 4 makes his first lookup.

These phase-by-phase profiles highlight two distinct VD appropriation styles: Sustained exploration for 1 and 3; Measured use for Pupils 2 and 4; and VD appropriation styles diverge: Pupils 1 & 3 explore more broadly (nouns/adjectives dominant), whereas Pupils 2 & 4 show measured use. Importantly, comprehension gains occur under both styles, and at times without extensive VD use (Pupil 4), underscoring non-causal, profile-dependent alignments between tools, gameplay, and test outcomes.

4.4. Pedagogical implications and limitations

In linguistically diverse primary classrooms in Romandy, a visual dictionary integrated in a CALL environment can serve as a flexible scaffold. Two practical takeaways emerge tentatively from our single-case evidence: Different profiles, different pathways: some learners appear to benefit from exploratory use (trying synonyms/illustrations), while others progress with minimal, targeted lookups. Teachers may therefore offer both modes intentionally (e.g., exploration time vs. pinpoint lookups during tasks). Also, feature timing matters: toggling supports, and adaptive pathways can lead to temporary dips before rebounds; planning guided transitions (e.g., modelling when to consult the VD) may stabilise performance during changes. Given the very small sample, these implications are provisional and intended to inform reflective practice rather than prescribe general solutions. This single-case exploratory study prioritizes process description over inference. The present analysis precludes generalization and causal claims. Measurement relied on construct-level test scores plus in-game traces; future work should examine larger cohorts.

5. Conclusion

This single-case study (N=4) in French-speaking Switzerland (Suisse romande) examined how primary FSL pupils appropriate a visual dictionary (VD) within a CALL environment and how these patterns align with gameplay trajectories and reading-comprehension outcomes. Two usage styles emerged—exploratory and measured—with trajectories shifting around feature toggling (Additional Features, Adaptive Learning) and selective, not uniform, construct-level changes, indicating profile-dependent, non-causal alignments between VD use, gameplay, and test change. Pedagogically, in multilingual Suisse romande classrooms the VD can serve as a flexible scaffold for both exploratory engagement and targeted lookups, with light guidance during feature transitions. Our results are exploratory and not generalisable; future work in Suisse romande and beyond should test these findings with larger, comparative, longitudinal designs.

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