

Teacher-Mediated Use of Digital Information Resources for Vocabulary Learning: Evidence from Kurdish EFL Learners

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Abstract

Digital information resources increasingly complement conventional instructional materials by providing interactive, contextualized, and multimedia environments for learning. However, evidence concerning the educational use of such resources in resource-constrained and multilingual learning environments remains limited. This study examines the teacher-mediated use of Trace Effects, an interactive digital educational resource designed to support contextualized language learning, among Kurdish English-as-a-Foreign-Language (EFL) learners in the Kurdistan Region of Iraq. An exploratory archival reanalysis was conducted using records from an eight-week, nonrandomized comparison involving 60 learners in two intact classes (N=30 each). One class used Trace Effects in an information-technology laboratory under teacher guidance, while the comparison class received conventional teacher-led vocabulary instruction. Both classes

completed the same researcher-developed 40-item vocabulary assessment before and immediately after instruction. The class using Trace Effects recorded a mean gain of 9.33 points compared with 4.00 points in the conventional class, representing a descriptive between-class difference of 5.33 points. Archived perception data further indicated that 80.0%–86.7% of learners using Trace Effects agreed or strongly agreed that the resource supported vocabulary recall, engagement, motivation, contextual understanding, learning beyond conventional materials, and future learning. Because each instructional condition comprised only one intact class, these differences cannot be interpreted as causal treatment effects. From a library and information science perspective, the findings highlight the potential relevance of teacher-mediated digital educational resources for extending access to contextualized and interactive learning content. The study further suggests implications for the selection, accessibility, mediation, and evaluation of digital learning resources by educators, librarians, information professionals, and learning-resource centres, particularly in multilingual and developing educational contexts.

Keywords: Digital Game-based Language Learning, L2 Vocabulary Learning, English as a Foreign Language, Trace Effects, Kurdish Learners, Intact-class Comparison.

Introduction

Digital technologies have substantially expanded the range of information resources available for educational purposes (Pino-Perdomo and Velásquez-

Mosquera, 2026; Razzaq et al., 2026). Educational information is no longer confined to textbooks, printed reference materials, or conventional databases but is increasingly encountered through electronic, multimedia, audiovisual, and interactive digital resources (Seaman and Seaman, 2021). These developments provide learners with new opportunities to access information through diverse formats and learning environments (Yin et al., 2026). However, the availability of digital technology does not necessarily guarantee meaningful educational benefits (Aljumah et al., 2026). There is still limited evidence on the added value of educational technology, and that the effectiveness of digital technologies is dependent on context, appropriate integration, and human interaction. This issue is particularly important in multilingual and developing educational contexts, where technological infrastructure, language, and institutional support may influence learners' ability to benefit from digital resources.

The expansion of digital information resources also affects the library, learning-resource centre and information professionals (Alazemi, 2022). Modern libraries offer access to information in a variety of media: print, audiovisual, and networked (Mammadov and Mahammadli, 2025). Meanwhile, librarians are more and more becoming intermediaries who are able to assist the user in the effective search, retrieval, interpretation and use of information. Digital information provision is not just about making information available (Anh and Khan, 2023) but also helping users to navigate increasingly complicated information contexts (Dusi, 2026). The issue becomes more significant in developing educational contexts, as the technological infrastructure, perceived usefulness, ease of use and match of the digital information system and the local users' situation can impact the adoption and meaningful use of digital information resources (Park et al., 2009).

Human mediation is particularly important when digital resources are interactive and combine multiple forms of information. Interactive resources can incorporate written and spoken language, images, animation, story, feedback, and task-based activities to ask users to navigate through the resource and relate various types of information to specific learning goals. From a library and information science perspective (Hjørland, 2000), this poses questions about the evaluation of interactive digital resources, ways of supporting users in accessing and working with interactive resources, and the role of human mediation

in meaningful interaction. Librarians are trained information intermediaries who inform users of information and assist them in mastering media and information literacy. Technology must not be used to replace human interaction in education (Xie et al., 2025). This principle is important to note because, although the present study is focused on teacher rather than librarian mediation, it offers an important context for understanding the use of interactive digital resources in education.

These are especially important for English as-a Foreign Language (EFL) learning (Abdul Aal, 2017; Al_Sawalha and Chow, 2012; Amirian et al., 2020), where digital resources can provide learners with language in the context of multiple modalities. Vocabulary knowledge is not just about knowing the meaning of single words, but also about knowing word form, meaning, associations, grammatical behaviour, collocation and appropriate use (Webb and Nation, 2017). One type of interactive digital resource is digital game-based language learning, where learners can experience the vocabulary of a language in a narrative, visual, auditory, and task-based environment. The studies in the literature have reported positive learning outcomes in digital game-based vocabulary learning, but the results are inconsistent, depending on the characteristics of the digital game, the characteristics of the learners, the instructional conditions, the amount of exposure, and the methods of assessment (Chen et al., 2018; Chowdhury et al., 2024; Dixon et al., 2022). Therefore, the educational benefit of an interactive digital resource must be taken into account in terms of how it is used and mediated the learning activities.

In this context, the present study explores the interactive digital educational tool in the context of teacher mediated EFL environment in the Kurdistan Region of Iraq (KRI) with regard to the study of Trace Effects. Trace Effects is a three-dimensional educational game created by the U.S. department of state, which introduces learners to written English, the visual environment, characters, situations, and language-mediated. The resource was used in the current instructional setting with teacher support: target vocabulary was introduced, orientation to the digital environment was given, supervision of the game was provided, and linguistic or technical support was offered as needed. Previous studies in the Kurdistan Region have addressed the issue of Trace Effects in the context of overall language proficiency and have explored the use of video games

in vocabulary acquisition with younger students (Ameen Bibani, 2024; Khidhir and Wali, 2019). But, there is not much evidence regarding the impact of teacher-mediated interactive digital educational resource and short-term vocabulary outcomes for Kurdish EFL learners.

Importantly, the present study is not a measure of information literacy, information-seeking behaviour, digital literacy or library use. Its importance to library and information science is rather in the wider context of the use of digital information resources and human mediation in an educational setting. This study focuses on an interactive resource that delivers information in several different ways, and how this resource was integrated into the teacher-led learning environment. There are no direct measures of information behaviour or information literacy in the available archive; it includes vocabulary-test scores and instructional documentation, as well as aggregate perceptions of the Trace Effects experience. Therefore, the present study remains distinct between the library and information science (LIS) context in which digital resources can be understood and the educational outcomes which were actually measured.

The present article presents a nonrandomized, two-class pretest–posttest study, which was explored through an archival reanalysis. One class was intact and was taught by the teacher with Trace Effects, while the other class (the comparison class) was taught by the teacher as a conventional class and was reported to be teaching the same vocabulary. The 8-week instructional period was followed by a researcher-developed 40 item vocabulary test, also administered prior to and after the 8-week period for both classes. Each instructional condition was represented by only one whole class, consequently the observed conditions cannot be dissociated from the characteristics of the class, including teacher, timetable, peer composition, baseline composition or instructional setting. Thus, the difference between the classes is not causal in the sense of being a treatment effect, but rather described as a difference. The purpose of the study is to describe the pretest to posttest changes in students' vocabulary-test scores to characterize the distribution of the gains across the two classes, and to summarize the perceptions of students that can be recovered from their experiences with the teacher-mediated Trace Effects experience. Finally, the study has following research questions:

RQ1. What pretest-to-posttest changes in proximal

vocabulary-test scores were observed in the teacher-mediated Trace Effects class and the conventional instruction class?

RQ2. How did the two observed classes differ in the magnitude and distribution of pretest-to-posttest vocabulary-test gains?

RQ3. What perceptions of the teacher-mediated use of Trace Effects were reported by learners in the intervention class in the recovered aggregate questionnaire summaries?

Literature Review and Interpretive Lenses

Digital Information Resources in Education

The educational information environment has shifted from a print-based information world to more diversified digital information world (Karintseva et al., 2020). In today technological environment, learners can experience educational information in many different ways (Bahri et al., 2026), through electronic books, online databases, digital repositories, audiovisual materials, open educational resources, multimedia learning materials and interactive applications. This change has led to an increase in the possibilities of educational material being available in a wider range of places and beyond the geographical and physical limits of traditional information institutions. Value of technology in education is dependent on how digital resources are used as part of the educational process (Salam et al., 2026).

This expansion from a LIS point of view alters the way that educational resources are provided. Along with the increasing availability of information in digital and multimedia formats, libraries and information institutions are also faced with the challenge of ensuring that information is accessible, usable, discoverable, and supported by users (Onunkaa et al., 2023). Digital resources can vary significantly in terms of their format, interface, navigation, language as well as technical requirements. The selection of resources involves more than just availability of content; there is also a need to consider whether the resource is suitable for the users' information and learning needs.

Digital education resources are also becoming more interactive, as opposed to informational. Interactive resources can include text, audio, images, animation, narrative, feedback, and user-controlled navigation. These resources can offer learning

opportunities in context as users are presented with information when they are engaged in a task or responding to a situation. Assessing digital education resources, it is important to consider both the content of the resource and how it can be used by the user to access that content. The present study explores Trace Effects as part of this overarching category of digital educational resources. While this is a digital learning game, it can also be considered a multimedia information environment where learners are exposed to written and spoken English, visual information, characters, narrative situations and task-related information.

Information Access and Use in Learning Environments

The availability of information electronically is not just an issue of resources being available technically. Access to information with regard to specific need is also covered by meaningful access, navigate, understand, evaluate and use information (Kuhlthau, 2025). The study of the adoption of digital libraries shows that the usefulness and ease of use of the digital information system may affect digital information system adoption and use, especially in developing countries (Park et al., 2009). Likewise, connectivity, availability of devices, digital skills, language, and contextual conditions as factors that can impact learners' access to the benefits of educational technologies.

Therefore, learning environments are an important setting in which digital information is gathered and used (Yin et al., 2026). Educational information can be accessed by the learner from education information resources chosen by the teacher, the library, a learning-resource centre or other institutional provider. The next use of the information may be through reading, listening, viewing, navigating, comparing, interpreting, responding, or applying the information to an educational task. These activities can take place concurrently in interactive digital environments where the learner must move through the resource and process the information being delivered in multiple modalities. The access distinction is especially important in multilingual education contexts. A resource might be technically available but not easily usable due to language, interface, content or technical requirements that do not match the users' needs. Access to digital resources might also be affected by infrastructural and institutional factors (KewalRamani et al., 2018). The above factors indicate that studies of digital educational

resources should not only address the availability of the resources but also how learners' access and engage with the information contained within the resources.

In the current study, access and use are related to a teacher mediated classroom setting. The learners used the Trace Effects in an institutional IT lab and individual interaction with the resource under teacher guidance. The teacher oriented and supported learners when language and technical issues impacted their learning. The archive offers evidence of the instructional context in which the resource was used, but does not include measures of individual information-seeking behaviour, resource discovery, or information-use strategies. Such differences must be taken into account when reading the study from the LIS context.

Information and Digital Literacy

The growing number of digital learning resources has also reinforced the significance of information and digital literacy (Mann, 2026). In the current learning contexts, users might need to locate information, interact with digital systems, evaluate information, interpret various formats, and apply information to specific purposes. The concept of media and information literacy is framed broadly in terms of people's ability to access, evaluate, organize, create and communicate information in various media and information environments (Koltay, 2011). Digital literacy also involves skills needed to engage with digital technologies and information in specific social and learning environments.

The concepts are applicable for the current study because the interactive educational resources involve the learners engaging with information on digital interfaces (Shank, 2013). The outcomes explored in the current research should not be confused with information literacy and digital literacy. The archived study did not contain measures of information literacy, digital literacy, information-seeking behaviour, or information evaluation that were validated. These concepts are only introduced as background information to the understanding of the overall information environment in which interactive digital resources are applied and not considered as tested variables or results. This difference also provides an important context to the current results. Any evidence of learner interaction with Trace Effects and positive perceptions of the resource does not constitute evidence of an improvement in information literacy or digital literacy. However, the study centers on the observable change in a proximal vocabulary

assessment and on the recoverable perceptions of the teacher-mediated digital learning experience.

Human Mediation of Digital Information Resources

Digital information resources do not replace human mediation (Singh and Kumar, 2024). In the field of library and information science (Hossain et al., 2026), mediation is a general term for the way information professionals facilitate the relationship between information and users, enabling them to locate, access, interpret and use information effectively. In the context of education, this mediating function can be played by the teacher, who links digital resources to educational goals and helps users when they come across conceptual, linguistic, and technical obstacles. Educational technology is not a replacement for teachers and other forms of educational support (Perez et al., 2026).

Human mediation particularly important for interactive and multimedia resources. Users may require support to locate the structure of a resource, information within a resource, unfamiliar content, technical features, and to link digital activities with learning goals. Mediation can also include the process of guiding learners to focus on the target language (Fathi and Rahimi, 2026), clarifying meanings, facilitating comprehension, and prompting learners to relate contextually mediated experiences to future learning in the target language. The role of teacher knowledge, curriculum alignment, digital game selection, and follow-up activities in the effectiveness of digital games as language learning environments has also been highlighted (Belda-Medina and Calvo-Ferrer, 2022a, 2022b). In the current study, this mediating function is illustrated in the role of the teacher. The teacher worked as an intermediary between the digital resource, the learning goals and the interaction of the learners with the resource.

Interactive digital resource takes place within a structured learning environment (Bikowski and Casal, 2018). It is not possible to attribute an observed learning change solely to the technological resource, without taking into account the mediation that is observed at the same time. Explanation, orientation, technical assistance, review of target vocabulary, learner interaction and the nature of the digital resource can work together. However, the documented instructional procedure shows the need for human mediation in the evaluation of interactive digital resources in educational information environments.

This distinction from an LIS perspective is an extension of the idea of digital resource provision. In the future, libraries, learning-resource centres and information professionals are likely to be presented with interactive learning resources which will ask users to navigate through the multimedia interfaces instead of just obtain and read information. The present study does not directly address the issue of librarian mediation, but rather a teacher-mediated classroom setting provides an illustration of a more general principle that will be explored in LIS.

Vocabulary Learning and Contextualized Retrieval

Breadth and depth are included in lexical knowledge. Whereas breadth refers to the number of known words, depth includes associations, collocations, grammatical patterning, register, and productive control (Webb and Nation, 2017). While explicit vocabulary work may be common in vocational L2 English classrooms, opportunities for productive use and self-directed strategy development are restricted (Skarpaas and Rødnes, 2022). Explicit, graphical explanations and flashcards can facilitate efficient form–meaning mapping; two contextual tasks provide use information. They are complementary, not mutually exclusive, functions. Similar meta-analyses of intentional vocabulary treatments and incidental exposure also show substantial immediate learning, but less durable effects on delayed measures.

Similarly, repeated exposure is more likely to afford retention when it requires active engagement or retrieval as opposed to passive re-reading. Hence, the deeper processing that is induced by searching for or evaluating meaning through a task and the retention benefits of distributed (Laufer and Hulstijn, 2001). The importance of emphasis, accuracy, repetition, time on task, elaboration, and motivation or self-efficacy. While narrative games perhaps instantiate several of these conditions when a player must know what to move the narrative forward, they also allow for guessing, for skipping description words that are not familiar or context incompletely understood, and shifting attention toward game mechanics instead. So, time spent in a game cannot be regarded as lexical learning.

Digital Games as Language-Learning Environments

DGBLL includes drill games, mobile apps, commercial entertainment titles, and fictional immersive narratives. They are distinct along many

dimensions, including the salience of linguistic input, opportunities for comprehension and production, feedback, collaboration, and curricular integration. Previous reviews typically highlighted positive pooled impacts on L2 vocabulary but also noted large variation between studies and common design weaknesses such as small samples, short interventions, proximity of outcomes and limited delayed testing (Acquah and Katz, 2020; Thompson and von Gillern, 2020). It follows that reviews and commentaries caution more against aggregating DGBLL into a homogeneous category of pedagogical intervention (indistinct from the “game” and “learner population”) than they do in terms of what learner outcomes or instructional mediation should be used. Gamification is related, but conceptually independent of DGBLL, so evidence herein cannot be substituted with findings from Gamification (Lee et al., 2025). More recent work differentiates between receptive and productive vocabulary knowledge, language-focused engagement versus game mechanic engagement.

This conditional picture is further underlined by individual studies. In studies with specific instructional conditions, structured mobile and online vocabulary games have been linked to superior performance or positive perceptions (Yip and Kwan, 2006). Calibrated feedback in immersive environments and gamification at the course level have produced short-term benefits that are not consistent across assessments (Panmei and Waluyo, 2023). Commercial simulations, for instance, may facilitate learning when follow-on tasks keep the focus on language (Ranalli, 2008), but interactivity can also direct cognitive resources to game mechanics instead of vocabulary. This, however, does not mean positive affective responses should be merely seen as a consequence of achievement.

This flow could also apply equally to those individuals who might not have previously reported a great deal of success with self-regulation and potentially account for learner heterogeneity. Longitudinal studies demonstrate the relationship between self-regulated strategy use and vocabulary development in game-based contexts. Game-induced flow may be only part of the picture; language-related flow also matters for incidental vocabulary learning (Karimi and Nasouri, 2024), and more recent modeling treats flow as a function of learner and context rather than game presence alone. These processes are only interpretive possibilities for those in the present archive, without being tested as mediators.

Interpretive Framework and Evidential Limits

This novel study, however, does not test a singular lens of explanation. Rather, the established accounts are employed to dissect what might be plausible explanations for the pattern in their classroom. The content of multimedia learning and cognitive-load theory indicates that when interface demands do not exceed processing capacity, corresponding verbal and visual information can provide favorable outcomes in learning (Sweller et al., 2019). Interactionist and sociocultural perspectives emphasize feedback, interaction, and teacher or peer scaffolding (Long, 1996), whereas self-determination theory offers a narrow perspective on the intervention-class perception items. Although these are high-level models, game-based-learning models move further toward defining outcomes as a function of interaction among dimensions of the game features, learner processes, and instructional design (Plass et al., 2015). Nevertheless, the archive has no cognitive load, retrieval frequency, time on task, self-regulation, and negotiation of meaning or mediation measures. As a result, these theories do not serve as the test mechanisms, potential mediators, or explanatory evidence in this study but rather provide an organization to our interpretation of future measurement priorities.

Contextual Gap and Bounded Contribution

Locally, research on Trace Effects, video-game-supported vocabulary learning, and teachers' perspectives are each part of a larger piece. Khidhir and Wali (2019) investigated more general linguistic competence with Trace Effects; Ameen Bibani (2024) explored vocabulary acquisition through video-game-supported learning among younger, public-school learners; and Abdullah et al. (2025) conducted interviews with ISCED-2 EFL teachers in the Kurdistan Region and Hungary, who identified time, materials, game selection, and institutional support as challenges in implementation. These studies provide some local evidence but face the methodological dilemma we address in this article: how to interpret short-term learner score change in a situation where one intact class corresponds with each instructional condition. The relationship of this research with this work is shown in Table 5 within Section 5.2.

Thus, this paper neither claims to be the first

local use of Trace Effects in a Kurdish context nor to perform games related to vocabulary. Its input is more limited: it records a 2022 young-adult technical-institute implementation, retains an auditable two-class score record, separates proximal test performance from intervention–class perceptions, and eliminates the one-class-per-condition confounding. The reanalysis is not a causal estimate of the effect of game against conventional teacher-led instruction, but rather provides methodological transparency in interpretation and analysis.

Method

Design and Setting

The original design and methods outlined a quasi-experimental pretest–posttest analysis at a private technical institute in the Kurdistan Region of Iraq. Assignment could not be made to individual students as instruction was delivered to pre-existing intact classes. In these studies, we consider this design more conservatively as a nonrandomized two-class comparison for the current reanalysis. The Trace Effects class was taught in the institute’s IT laboratory while a comparable class received conventional teacher-led instruction in a classroom, both having been taught by their regular English teachers and limited to these two intact classes of 30 learners. The eight weeks of teaching commenced on 20 October 2022. The pretest was carried out prior to the instructional period, followed by a posttest immediately after the 8th week.

In that sense, the study is neither a true randomized trial nor an appropriately replicated cluster comparison, and the archive cannot have any potential to determine a treatment effect. The class was therefore the assignment unit, and only two assignment units were observed. With one class per condition, condition is completely confounded

with class-level characteristics such as teacher, timetable, peer composition, baseline composition, and instructional setting (Murray et al., 2004). Therefore, it is neither a randomized trial nor a sufficient cluster replication comparison study, and the archive cannot separate out the treatment effect.

For the reanalysis, we utilized three of the retained sources: (a) analytical workbook; (b) summaries of aggregated questionnaires; and (c) methods document. Weekly structure, procedures for instrument development, and the original software used for analysis are reported only when specifically documented in the record of methodology. The start date, 20 October 2022, was confirmed separately by the authors. Item-level responses, expert-review forms, attendance logs, signed consent forms, and the host-site authorization document are not available for independent verification. These absences are treated as provenance limitations and are not reconstructed.

Participants

Sixty-three students were enrolled in the English Department at the time of the study. Three completed a preliminary instrument pilot and were excluded from the main sample, leaving 60 Kurdish EFL learners in two intact classes (N=30 per condition). All were 19 or older; 57 of 60 (95.0%) were aged 19–22. Twenty-one were male (35.0%), and 39 were female (65.0%). The original methodology described the classes as comparable in baseline English proficiency and reported completion of the institute’s basic placement assessment. Placement scores were not retained, and the vocabulary pretest means differed by 2.67 points, so baseline equivalence is not claimed. The analytical sample is the 60 main-study participants with complete pretest and posttest totals. No prospective class-level sample-size calculation was documented. Table 1 summarizes participant characteristics.

Table 1: Participant Characteristics.

Characteristic	Trace Effects (N=30)	Comparison (N=30)	Total (N=60)
Male, n (%)	11 (36.7)	10 (33.3)	21 (35.0)
Female, n (%)	19 (63.3)	20 (66.7)	39 (65.0)
Age 19, n (%)	Not retained	Not retained	21 (35.0)
Age 20, n (%)	Not retained	Not retained	16 (26.7)
Age 21, n (%)	Not retained	Not retained	11 (18.3)
Age 22, n (%)	Not retained	Not retained	9 (15.0)
Above 22, n (%)	Not retained	Not retained	3 (5.0)

Note: Group-specific age distributions were not retained; unavailable cells have not been reconstructed.

Instructional Conditions

The intervention lasted eight weeks from the author-confirmed start date of 20 October 2022. The Trace Effects class met weekly in the institute's IT laboratory. Week 1 was an orientation to the game and to study procedures. In each of the next seven weeks, learners completed one chapter. The instructor briefly reviewed the target vocabulary before play. During play, learners moved through the three-dimensional environment, interacted with objects and characters, listened to audio, followed dialogue, solved language-mediated tasks, and responded to situational prompts. Correct responses allowed progress; incorrect responses were followed by contextual hints.

Gameplay was completed individually under instructor supervision. The instructor established common learning objectives, provided interface orientation, and offered linguistic or technical assistance when difficulties prevented progress, but the original methodology indicates that the instructor did not solve the in-game tasks for learners. Students with limited digital literacy could receive occasional peer assistance for basic software navigation or troubleshooting; such help was restricted to operating the software and did not include selecting vocabulary answers. The original methodology reports that the comparison class received conventional teacher-led vocabulary instruction targeting the same vocabulary in a separate instructional room. Because the target-word list and detailed lesson plans are not retained, this cross-condition content alignment is treated as a reported methodological feature rather than as independently verified equivalence.

Exact session minutes, attendance, teacher identity, out-of-class exposure, technical interruptions, contamination checks, and fidelity logs are not retained (Table 2). Whether the same instructor taught both classes cannot be verified, so exposure equivalence is not established. The contrast is therefore between two class-based instructional packages, not an isolated test of one game feature.

Figures 1–3 show the Trace Effects interface used in the IT laboratory. Figure 1 is the first-person scene with an on-screen objective, compass, and chapter score. Figure 2 is the Chapter 1 completion screen, which lists can-do statements and offers language practice, a graphic novel, replay, or the next chapter. Figure 3 is a comic-style cloze activity in a student-services encounter.

Table 2: Instructional Implementation Compiled from the Retained Archive, Original Methodology Documentation, and the Author-confirmed Study Start Date.

Feature	Comparison	Trace Effects
Class size	30 learners	30 learners
Instructional setting	Separate conventional classroom	Institute IT laboratory
Study period	8 weeks; start 20 Oct 2022	8 weeks; start 20 Oct 2022
Session structure	Conventional teacher-led instruction throughout study period	Weekly sessions; Week 1 orientation + 7 chapters
Reported target-content alignment	Original methodology reports the same target vocabulary	Original methodology reports the same target vocabulary embedded in game dialogue, audio, objects, prompts, and problem solving
Teacher/support	Teacher-led explanation and practice; documented flashcard activities	Pre-game vocabulary review; supervision; interface/linguistic/technical support; peer help limited to navigation
Outcome measure	Same 40-item test at pretest and immediate posttest	Same 40-item test at pretest and immediate posttest
Still not retained	Session minutes; attendance; teacher identity/equivalence; contamination/fidelity logs	Session minutes; attendance; teacher identity/equivalence; out-of-class exposure; technical/fidelity logs



Figure 1: Main Gameplay Interface of Trace Effects: First-person Scene, On-screen Objective, Compass, and Chapter Score.

Source: U.S. Department of State, Trace Effects (American English, n.d.).



Figure 2: Chapter 1 Completion Screen, with Can-do Statements and Options for Language Practice, a Graphic Novel, Replay, or the Next Chapter.

Source: U.S. Department of State, Trace Effects (American English, n.d.).



Figure 3: Comic Cloze Activity Set in a Student-services Encounter, Illustrating Context-obligated Vocabulary use Required for Chapter Progression.

Source: U.S. Department of State, Trace Effects (American English, n.d.).

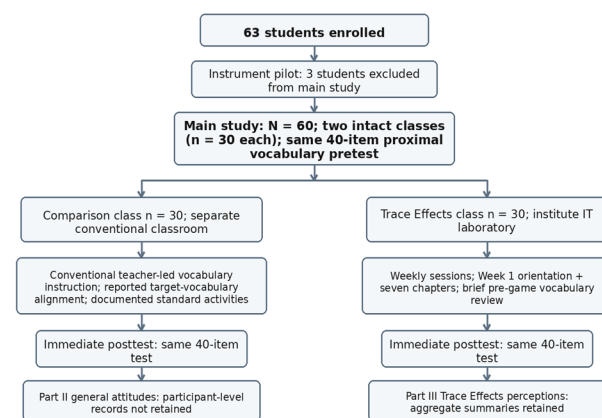
Measures

Proximal Vocabulary Test Measure: The primary outcome measure was a 40-item questionnaire created specifically for the study, comprised of four sections. The test included multiple-choice fill-in-the-blank items to gauge contextual vocabulary application, as well as sections on synonym identification, word associations, and basic word recognition by matching. Each correct answer generated one score point, resulting in a total score that ranged from 0 to 40. The same test was given at both pretest and posttest so that performance could be assessed on a common measure. The development of the original methodology includes a content review by three assistant professors who are experts in English language teaching and educational technology, and minor wording and organizational changes. This paper additionally presents a preliminary pilot involving three students to explore clarity of the test directions and completion time, with a Cronbach's alpha coefficient of .817. But the paperwork that has been kept does not specify the test or sample from which the .817 coefficient was determined, and the archive lacks a complete item set, target word list, expert-review forms, participant-level item responses, or the original reliability output. Thus, the coefficient is only reported as an original methodological record and constitutes no independent evidence of reliability. It is not possible to re-estimate item difficulty, discrimination, dimensionality, or internal consistency independently. Once again, testing familiarity could explain pretest–posttest improvement because the same test was re-administered (Hausknecht et al., 2007). Thus, the result is construed as performance on a researcher-developed proximal vocabulary test claimed to reflect the vocabulary target of instruction rather than some validated index of general vocabulary knowledge.

Post-intervention Questionnaire: The methodology itself describes a structured questionnaire divided into three parts. Part I collected demographic information. Each class reportedly completed Part II, which consisted of six five-point Likert items on general attitudes toward using video games to learn English vocabulary. Part III consisted of six five-point Likert items about pedagogical value; only the Trace Effects class filled in these archived labels for usefulness: perceived ease of remembering new words; how engaged/enjoyed he/she enjoyed learning

English; his/her motivation to learn more and practice beyond the textbook; understanding meaning and use in context; and future use of English classes. It detailed the expert reviews of the questionnaire by three experts in educational technology and English language teaching. Individual questionnaire records are not available, but the manuscript of the original study contains item labels and summary response distributions for six Trace Effects-specific items. Supplementary Table S2 shows the archived labels and their percentages. The revision materials retained cannot independently reconstruct the exact wording of the original item. Part II is not analyzed in the present archival reanalysis because its participant-level records and item-level denominators are unavailable for independent verification. Part III is reported item by item as descriptive perception/acceptability evidence; no scale reliability, factor analysis, composite score, or inferential test is constructed without participant-level responses.

Procedure



Eight-week intervention beginning 20 October 2022; Immediate posttest after completion.

Figure 4: Study Flow Reconstructed from the Original Methodology and Retained Analytical Archive, using the Author-confirmed 20 October 2022 Start Date. Target-vocabulary Alignment in the Comparison Condition is Reported in the original Methodology; Detailed Lesson Materials and the Target-word List are not Retained.

Data collection followed three documented stages. Before instruction, participants were informed about the study, provided written informed consent, and completed the 40-item vocabulary pretest. The eight-week instructional period began on 20 October 2022. Immediately after week 8, both

classes completed the same test as the posttest. Part II of the questionnaire was reportedly completed by both classes and Part III by the Trace Effects class only; the present reanalysis uses only the recoverable aggregate Part III summaries. The workbook contains complete pretest and posttest sections and total scores for all 60 main-study participants. Unavailable implementation and consent records are identified in Section 3.3 and Table 2. Figure 4 summarizes the documented sequence.

Ethical Considerations

The available ethics approval letter is dated 10 October 2022, preceding the documented study start on 20 October 2022. Identifying committee and application details are provided separately in the title page and ethics documentation to preserve double anonymization. The original methodology reports written informed consent from all participants after information about the study, voluntary participation, withdrawal without penalty, confidentiality, and anonymous research use of their data; it also reports host-site authorization. Signed consent forms and the host-site authorization document are not part of the retained revision archive.

Statistical Analysis and Inferential Scope

The original methodology reports analyses in IBM SPSS Statistics (Version 29), including descriptive statistics, independent-samples and paired-samples *t* tests, a mixed-design ANOVA, Cohen's *d*, and $\alpha = .05$. These procedures are part of the historical study record but are not used in the present reanalysis to support a treatment-effect claim. The assignment unit was the intact class rather than the individual learner, and only one class represented each condition (Campbell et al., 2012).

The present analysis is descriptive. For each class, summary statistics are provided for pretest, posttest, and gain scores (posttest- pretest) in the form of *n*, mean (standard deviation), median (interquartile range), range, and improvement/decline counts, as well as a 10% trimmed mean when relevant. Regarding RQ2, we captured the raw difference between class mean gains and the overall reported distributions of gain. There is no replication at the assignment-unit level, and so any standard error, *p*-value, confidence interval, or standardized effect associated with any between-condition contrast cannot be interpreted

as a treatment-effect estimates. The two observed classes used only scenario data are calculated at the participant level.

The design repair of using a pretest-adjusted ANCOVA is not employed. As there is only one class per condition, and the random class-level allocation is not documented, participant-level covariate adjustment can no longer disentangle condition from class. Gain scores facilitate transparency of observed change but do not eliminate baseline imbalance, selection bias, or confounding at the class level. All numerical summaries reported in the reanalysis were recalculated from the archived workbook using Python 3.12.13, pandas 2.2.3, NumPy 2.3.5, and SciPy 1.17.0. Reporting is guided by transparency principles for nonrandomized intervention evaluations (Des Jarlais et al., 2004).

Use of Generative AI in Manuscript Preparation and Verification

During manuscript preparation, generative AI (ChatGPT) was used for English-language editing, structural organization, and help in writing Python code to recalculate descriptive summaries from the archived workbook. The participant data were not generated or modified by the tool. The authors checked the recalculated figures and the high-risk bibliographic, DOI, and cited web-source metadata against the archive and against authoritative records, and they reviewed all AI-assisted text. Responsibility for the manuscript remains with the authors. OpenAI ChatGPT (GPT-5.6 Sol) was used during manuscript revisions on 10–11 and 22 August 2026.

Results

Participant Flow and Baseline Pattern

Sixty-three students were enrolled at the site. Three participated in the instrument pilot and were excluded from the main study, leaving 60 learners with complete pretest and posttest totals (30 per intact class). Although the original methodology described the classes as comparable in baseline English proficiency, placement scores are not retained. The retained vocabulary pretest means were 19.13 (*SD* = 5.92) in the Trace Effects class and 16.47 (*SD* = 4.34) in the comparison class, an approximate 2.67-point difference based on unrounded participant-level values. The reanalysis therefore does not assume baseline equivalence.

Proximal Vocabulary-Test Performance

Descriptive pretest, posttest, and gain-score summaries are presented in Table 3.

The Trace Effects class mean increased from 19.13 (SD = 5.92) to 28.47 (SD = 4.31), corresponding

to a mean gain of 9.33 points. The comparison class means increased from 16.47 (SD = 4.34) to 20.47 (SD = 4.34), corresponding to a mean gain of 4.00 points. The uncorrected difference in the two observed class mean gains was 5.33 points.

Table 3: Descriptive Proximal Vocabulary-test Scores in the Two Observed Classes.

Condition	Pretest M (SD)	Posttest M (SD)	Gain M (SD)
Trace Effects	19.13 (5.92)	28.47 (4.31)	9.33 (5.11)
Comparison	16.47 (4.34)	20.47 (4.34)	4.00 (7.05)

Note: Gain = posttest minus pretest; score range = 0–40. Gain and difference estimates were calculated from unrounded participant-level values; minor discrepancies may therefore occur when subtracting displayed rounded means. Values are descriptive summaries of the two observed classes and are not cluster-adjusted treatment estimates.

Both classes of gain distributions showed intra-class heterogeneity. The median gain in the Trace Effects class was 10.5 points (IQR = 5.25–12.75; range = –1 to 19); improvement occurred in 28 of the 30 learners, one learner had no change, and one learner declined. Among this comparison class, the median gain was 6.0 points (IQR = 2.0–8.0; range = –12 to 20); 23 of 30 improved, two were unchanged, and five declined. The poorest observed change, which was –12 points in the control class, cannot be attributed to attendance, engagement, instructional

exposure, or disruption because that type of analysis can only be conducted with a retained archive. Gains in the 10% trimmed mean were 9.50 and 4.54 points, respectively, thus implying that after mitigating the impact of the most extreme values, the direction of the contrast in descriptive class remained unchanged. These distributions are given in supplementary table S3. Class means only are shown in Figure 5, implying that they should be interpreted alongside the distributional statistics.

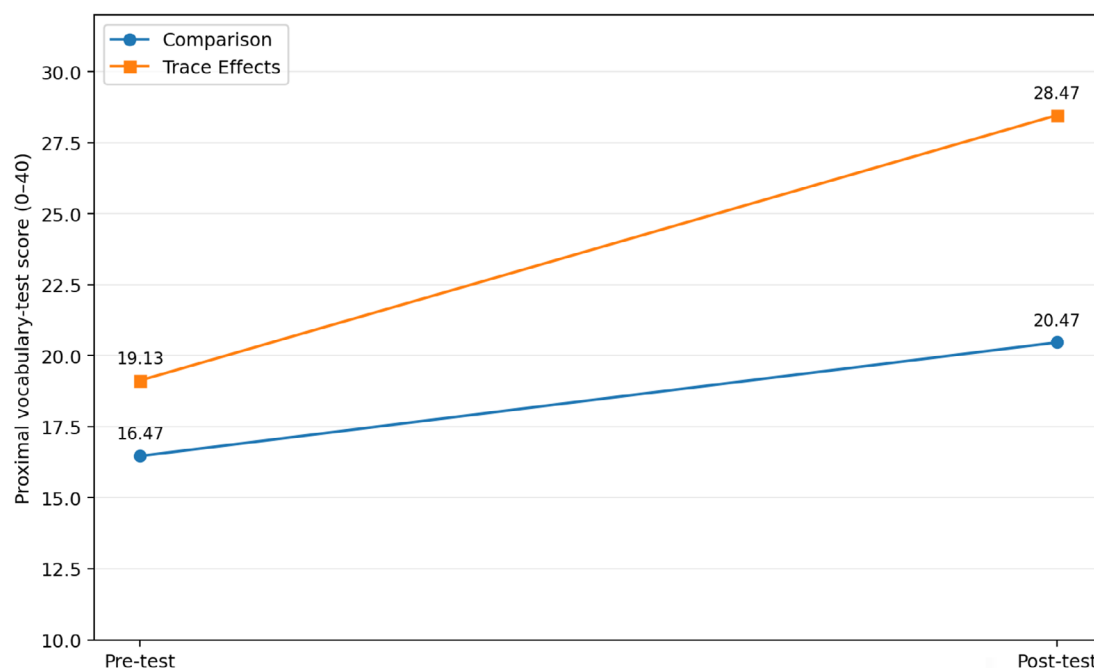


Figure 5: Mean Pretest and Posttest Scores in the Two Observed Classes (N=30 per class). Lines Connect Class means only. Spread, Including the Five Comparison-class Declines, is Reported in the Text and in Supplementary Table S3. The Display is Descriptive and is not a Treatment-effect Plot.

Evaluation of Trace Effects

The results from Part III summaries from the previous years were positive across all six Trace Effects-specific items. Agreement or strong agreement ranged from 80.0% for increased motivation to 86.7% of students finding it easier to remember English words and skills that would be useful in future English classes. Reports are provided separately rather than

in a scale, as only aggregate Part III summaries were retained and the items relate to different perceptions. There is no analysis of Part II because there are no participant-level responses and item-level denominators that may be independently verified. The recoverable Trace Effects specific perception table is presented in summary form in Table 4.

Table 4: Archived Part III *Trace Effects* Perception Summaries in the *Trace Effects* Class (N=30).

Evaluation item	Strongly agree (%)	Agree (%)	Agree / Strongly agree (%)
Helped me remember new words more easily	50.0	36.7	86.7
Was engaging and enjoyable	53.3	30.0	83.3
Improved my motivation to learn vocabulary	46.7	33.3	80.0
Supported practice beyond the textbook	43.3	40.0	83.3
Supported understanding of meaning and use in context	36.7	46.7	83.3
Should be used in future English classes	56.7	30.0	86.7

Note: Percentages are derived from the full Part III summaries stored in the archives. As no scale score, even just a reliability estimate, a factor analysis, or an inferential test can be rebuilt from aggregate percentages, participant-level questionnaire responses are missing. Item labels correspond to the archived summaries, and the wording of the original questionnaires is not reproduced verbatim. These archived labels and percentages were reproduced in Supplementary Table S2.

Discussion

Principal Findings and Evidential Meaning

After eight weeks, both classes had higher mean scores on a common 40-item proximal test (mean gains of 9.33 versus 4.00 points) for the Trace Effects class. This 5.33-point difference is descriptive of the two observed classes, rather than a causal estimate of the effect of playing the game. The result of the gain distributions shows that this change did not happen evenly. This process of comparing with a comparison class is only partially accurate: in this comparison, five learners would actually lose points, while others gain significantly. The impacts of the instructional condition or any other cause cannot be ascribed to these individual trajectories because attendance, session duration, teacher identity, and implementation disruptions were not retained. The distributional heterogeneity thus complicates, rather than alleviates, the burden of circumspect class-level interpretation.

A second constraint comes in the form of baseline imbalance. For example, the Trace Effects class started about 2.67 points higher, and the rule that assigned a split in assigning the two intact classes is undocumented. Although gain scores measure change,

and thus they cannot adjust for selection bias or for class-level confounding; more importantly, it follows that person-level adjustments cannot create replication at the assignment-unit level (Van Breukelen, 2006). The archive supports an entire 60-learner score record, a recoverable weekly protocol, and distinct proximal test performance from intervention-class perceptions. These are the features that constitute the evidential contribution of the reanalysis.

Interpretation in Relation to Prior Research

The observed class contrast direction corresponds with syntheses that report large average DGBLL effects and marked heterogeneity across research design, comparison conditions, and quality of assessment (Acquah and Katz, 2020). Reviews of gamification are comparably qualified (Lee et al., 2025), and L2 accounts focus on the interaction of software, learners, pedagogy, and context rather than just software (Cornillie et al., 2012). This consistency is contextual rather than confirmatory: because the instructional packages and outcome measures differ across studies, the raw 5.33-point difference on the present study-specific 40-item test cannot be directly benchmarked against pooled standardized effects.

Table 5 situates the present archive relative to the closest Kurdish evidence. Khidhir and Wali

(2019) used the same game but examined broader linguistic competence rather than a 40-item proximal vocabulary test and did not use the same analytical unit or recovered protocol. Ameen Bibani (2024) examined video-game-supported vocabulary learning among younger public-school learners using a different game, age band, setting, and instruments. Abdullah et al. (2025) examined teacher perspectives on collaborative game elements and implementation constraints rather than learner achievement. The

present study is therefore locally related to, but not a replication of, these studies. More broadly, short-term digital-vocabulary gains have varied across assessments (Panmei and Waluyo, 2023), and syntheses of intentional and incidental vocabulary learning show attenuation from immediate to delayed testing. These findings further caution against treating the present 5.33-point descriptive difference as a transferable effect magnitude.

Table 5: Local Studies of Games and English Learning in or Including the Kurdistan Region, Placed beside the Present Record.

Study	Distinction from the Present Record
Khidhir and Wali (2019)	Same game (Trace Effects), but broader linguistic competence and another analytical unit.
Ameen Bibani (2024)	Vocabulary via video games among younger public-school learners; unlike this study in game, age, and instruments.
Abdullah et al. (2025)	Teacher interviews in the Kurdistan Region and Hungary; implementation perceptions, not learner scores.
Present study	Young adults at one private technical institute; one class per condition; a 40-item test reported as an audit.

Note: Entries summarize what the present article can document about each study. Sample sizes, test scores, and unrecovered design details are not reconstructed. Abdullah et al. (2025) is a teacher-interview study, not

an achievement comparison.

One plausible interpretation is that Trace Effects made some lexical encounters consequential by linking dialogue, images, actions, and task outcomes, which is compatible with immersive-vocabulary evidence (Legault et al., 2019). A competing interpretation is that an unfamiliar three-dimensional interface imposed extraneous cognitive demands that could divert attention from language (Sweller et al., 2019). This indicates that flow may also not depend solely on game presence, but rather on learner and context. None of these hypotheses was put to the test. This study did not record target-word encounters, cognitive load, help requests, time on task, or teacher prompts, and so mechanism-level inference is unwarranted.

The lack of efficacy data is supported by the Part III summaries because of the difference between perceived acceptability and perceived efficacy here. The majority of the intervention-class learners endorsed statements relating to better remembering, enjoyment, motivation, contextual support, and use in the future. The above responses are consistent with models connecting perceived usefulness to actual use (Chen and Zhao, 2022), but they could also reflect novelty or demand characteristics, aspects of the laboratory environment. These alternatives cannot be disentangled as there is no comparison-class attitude measure nor participant-level questionnaire records available. Positive perceptions are not evidence for the

proximal test, cannot indicate a learning mechanism, or demonstrate instructional effectiveness. This means that the theoretical accounts discussed in Section 2.3 still exist as hypotheses for future measurement, and do not amount to conclusions from the current archive.

Implications for Library and Information Science

The findings have implications for library and information science (LIS), particularly regarding the selection, mediation, and provision of interactive digital educational resources. These implications should be interpreted cautiously because the present study did not examine libraries, librarians, information professionals, or library users. Rather, the study provides an educational case in which learners interacted with an interactive digital resource under teacher mediation. The LIS implications concern how similar resources might be considered and supported within educational information environments.

Digital Resource Selection

First, the study highlights the importance of evaluating interactive digital resources on dimensions beyond their technical availability. Trace Effects presents information through written and spoken language, visual environments, narrative situations, and task-based interaction. Its potential

educational usefulness depends partly on how these features correspond with users' learning needs and the objectives of the educational setting. For libraries and information professionals supporting educational institutions, this suggests that interactive resources may need to be evaluated according to usability, curriculum relevance, accessibility, learner characteristics, language, technical requirements, and the quality and appropriateness of the information presented. The availability of a resource in a digital collection should not be treated as evidence of its suitability for educational use. Such evaluation is consistent with the broader LIS emphasis on connecting users with appropriate information resources and supporting effective access and use.

The present case also demonstrates why learner characteristics should be considered during resource selection. Trace Effects was designed for younger learners, whereas the participants in the archived study were young adults. The resource may nevertheless have provided useful opportunities for contextualized language exposure, but the available data cannot establish whether its design was optimally suited to the participants' age, proficiency, or prior digital experience. Future resource-selection processes should consider the characteristics of intended users rather than assuming that a resource is educationally appropriate simply because it contains relevant content.

Information Mediation

Secondly, the study emphasizes the need for mediation between the user and the interactive digital resources. This Trace Effects class did not just get access to the software. The teacher introduced target vocabulary, oriented learners to the digital environment, supervised gameplay, and gave linguistic or technical support when difficulties made it impossible to progress. The teaching package was a blend of digital and human resources. This mediation cannot be credited independently for the gains in vocabulary observed in the study, as this study did not isolate the effect of teacher support from the effect of the digital resource. However, as the documented procedure, access and meaningful use are not the same.

This distinction is important for LIS because information professionals are often considered as intermediaries between users and information resources. The importance of the libraries and information professionals as facilitators of users'

access and effective use of information. For interactive learning tools, mediation can include introducing the user to an unfamiliar platform, explaining the features of the resources, helping the user navigate the resources, resolving accessibility issues, and linking available resources to their information or learning needs. The results of the present study do not prove the effectiveness of the mediation of the librarian; it only shows that in order to make the interactive resources meaningful, mediation by the librarian is needed. Rather, it proposes that resources should be accompanied by the right orientation, contextualization and user support.

Learning-Resource Centres and Libraries

Thirdly, the research has implications for the way learning-resource centres and libraries can facilitate access to interactive educational resources. In the context of educational libraries, the environment in which the user is required to access not only books and electronic texts, but also other learning resources, such as multimedia and digitally mediated learning is becoming more and more common. Libraries and learning-resource centres can offer an institutional context where learners can access these resources, where learners have unequal access to devices, connectivity, software or technical support. They might provide appropriate devices and connectivity, guide learners to find digital resources, orient learners to unfamiliar digital resources, offer assistance with basic navigation, help learners locate digital resources that align with their learning needs.

These opportunities are not necessarily a result of the present study, but rather service implications. The study cannot determine whether such services exist, whether they are effective, or how learners would respond to them in a library, learning-resource centre, or information professional. However, the teacher-mediated implementation is an example of support that might be used in future research related to library and information services for interactive learning resources. Specifically, future studies might focus on how libraries and learning-resource centres can work with teachers to find suitable interactive resources to make them available and to offer technical assistance, and to create guidance for learners to use multimedia information resources in relation to specific educational goals.

Theoretical and Methodological Implications

The study provides no principled basis for choosing among alternatives such as multimedia, cognitive-load, interactionist, sociocultural, motivational, or self-regulatory explanations because the relevant processes were not measured. As such, its value for theory is diagnostic - future research should operationalize and test candidate mechanisms separately from proximal achievement and acceptability. This distinction is necessary because similar posttest patterns could result from combinations of different predictors, such as retrieval opportunity and mediation by the teacher, interface demand, prior gaming experience, or time on task.

From a methodological perspective, the archive shows how, in classroom studies of educational technology, the unit (and often also strength) of inference must be dictated by which kind of assignment was done. With one intact class for each condition, observations at the learner level increase descriptiveness within those classes, but do not provide independent experimental replication of the instructional contrast. Thus, a firmer design requires multiple classes per condition, an allocation procedure that is prespecified, cluster-aware analysis, independently documented exposure and fidelity, and measures of outcome for which validity can be assessed from remaining item-level evidence.

Pedagogical and Implementation Implications for Future Evaluation

Subsequent evaluations should retain and capture the teacher-mediated framing of the instructional package rather than simply treating Trace Effects as an isolated software treatment. Teachers need to evaluate linguistic affordances, align contexts with target language, anticipate technical and cognitive barriers, and plan for retrieval or productive follow-up. For example, a prospective evaluation could: specify the target-word set ahead of time; orient learners to game content that aligns with the curriculum being taught; use focused play sessions; and end with explicitly planned retrieval or production tasks. Session logs should catalog the duration of each session, activities completed, interruptions, teacher elaborations, learner scaffolding, and protocol violations to allow evaluation of fidelity. Implementation conditions include proper documentation of hardware, audio, electricity, and technical support in the laboratories, as well as technical initiations.

Future use with young adults, based on the official resource targeting players from 12–16 years currently, should be judged by task relevance and acceptability rather than through expertise-based assumptions of age-appropriateness. The current archive is also insufficient to provide support for recommendations around institute-level or regional adoption. Decisions like this would necessitate replicable evidence across classes and sites, enhanced outcome measurement, and recorded fidelity of implementation.

Limitations

First, every condition corresponds to exactly one intact class. Differences in the teacher, timetable, peers, baseline composition of trial and control groups, or other class-specific characteristics may account for some or all of the variation observed. The class-allocation rule has not been documented, and the Trace Effects class had a slightly higher mean baseline score on the vocabulary pretest. However, it cannot recover from a lack of replication at the condition level by computing learner-level results.

Second, the 40-item outcome measurement is not independently validated but is from this retained archive. A three-student pilot, expert review, and Cronbach's $\alpha = .817$ are methodological records from history; the sample that underlies the coefficient, the item bank as a whole, the list of target words, and/or output from initial reliability are not saved. Actually, using the same test form gives a plausible practice effect. Thus, the measure should be viewed only as a proximal assessment of alignment with something traditionally taught in schools, and not a definitive demonstration of generalizable vocabulary development. The Trace Effects tracing class also provides more target vocabulary review during the pre-game period, and prevents a purely gameplay interpretation of the contrast between classes.

Third, if the weekly protocol is being recovered, exposure and teacher equivalence are not. Details including session minutes, attendance, teacher characteristics, exposure to English outside of class, technical difficulties, and fidelity logs are absent. There was no delayed posttest, although both incidental and intentional vocabulary learning syntheses suggest that immediate performance usually exceeds delayed retention.

Fourth, only summaries of Part III perceptions, at the aggregate level, are retained. It is not as though

Part II can be reconstituted from records which in some ways are independently verifiable at least by mechanical means. For the six items on Part III, these are descriptive acceptability indicators and not a validated scale, and they were completed only by the intervention class.

Fifth, the sample size is small; it consists of 65% female and is limited to one private technical institute. The learners were young adults using a game originally aimed at adolescents. It remains, therefore, unclear whether it generalizes to public schools, other age groups, other levels of proficiency, or other settings. Full pretest and posttest totals were present in all 60 main-study records, but the attendance log was absent; without an attendance log, complete outcome records cannot be determined independently.

Directions for Future Research

However, the existing 2022 archive should not be broadened retrospectively into a multi-class trial. A prospective study could preserve the implementation of an eight-week structure orientation, seven chapters, teacher-directed play, and a traditional comparison addressing the same words while repairing the design, in a study such as your second one, planned and preregistered in applied linguistics. Preregistration should, at a minimum: (a) provide a number of intact classes per “condition” and an allocative rule for writing class-allocations; b) use cluster-aware analysis with class as the clustering unit and only one confirmatory contrast; (c) directly compare parallel forms in separate blocks or counter-balanced rather than across item variability, retain test blueprints, item statistics and run reproducibility check; d) report session length/duration attendance/absentees teacher identity interruptions contamination checks; e) include delayed posttest with distinct receptive & productive outcomes; f) request participant-level questionnaire data along with prespecified subsequent reliability analysis accept planned tests of associations between perceptions and gains; and g) include prespecified robust summaries to describe gain distributions so declines/extremes remain visible.

Subsequent mixed-method and multisite research could then examine candidate mechanisms such as retrieval variety, audiovisual context, feedback, novelty, teacher mediation, and differential time on English. Moderation by proficiency, digital access, prior gaming experience, gender, and age should be

evaluated only in samples with sufficient numbers of classes and learners to support defensible subgroup analysis.

Conclusions

This exploratory study examines the use of an interactive digital educational resource, Trace Effects, in relation to vocabulary learning among Kurdish EFL learners. Across two intact classes, the teacher-mediated Trace Effects condition shows a larger pretest-to-posttest vocabulary gain than the conventional instruction condition. Learners in the intervention class also report generally positive perceptions of the resource. These findings suggest that interactive digital resources can provide a useful context for contextualized vocabulary exposure and retrieval when integrated with structured classroom instruction. However, because the study uses one intact class per condition and does not include random assignment, the observed differences should be interpreted as class-level patterns rather than as evidence of a causal treatment effect.

The study also highlights the importance of teacher mediation in the use of interactive digital learning resources. In the present context, mediation includes vocabulary preparation, orientation to the resource, supervision, and linguistic and technical assistance. These practices indicate that access to an interactive resource alone does not necessarily ensure meaningful educational use. At the same time, the study does not isolate the independent contribution of teacher mediation and therefore does not establish mediation as a causal mechanism. Beyond its language-learning context, the study demonstrates the importance of considering interactive educational technologies as digital information resources whose educational value depends not only on availability but also on appropriate selection, access, user orientation, and human mediation. Libraries and learning-resource centres can potentially contribute to this process by facilitating access to digital learning resources and supporting their effective use. This perspective extends the relevance of interactive educational technologies to Library and Information Science by highlighting questions of resource accessibility, usability, mediation, and user support. Future LIS research should directly investigate librarians’ and information professionals’ roles, learners’ information practices, digital-resource

accessibility, and information-literacy outcomes across different institutional and geographical settings. Such research can provide stronger evidence on how digital information resources can be selected, mediated, and supported to promote meaningful learning.

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Supplementary Materials

Supplementary Tables S1–S3 are provided in a separate supplementary file. Table S1 documents the provenance of key methodological details; Table S2 reports the archived Trace Effects-specific perception labels and aggregate percentages; and Table S3 reports the gain-distribution summaries from Section 4.2. These tables add no new observations and do not convert descriptive records into a treatment-effect estimate.



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