

The Effectiveness of Project-Based Learning Approach with IR4.0 Integration on Mastering Spanish Vocabulary Among University Students in Malaysia

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ABSTRACT

This study investigates the effectiveness and pedagogical appropriateness of integrating Project-Based Learning (PBL) with Industry 4.0 (IR 4.0) digital tools in enhancing Spanish vocabulary mastery among Malaysian university students. Grounded in constructivist and experiential learning theories, the study adopts a mixed-methods exploratory design employing a one-group pre–post quasi-experimental approach with embedded qualitative data. Quantitative data were obtained from vocabulary pre- and post-tests as well as writing and speaking assessments linked to a video-based project, while qualitative data were collected through semi-structured interviews and classroom observations. Participants comprised 24 undergraduate students enrolled in a Level 3 Spanish course at a public university in Malaysia, with eight students purposively selected for the qualitative phase. Quantitative findings revealed a statistically significant improvement in vocabulary performance from pre-test to post-test, with a large effect size, indicating the strong impact of the PBL + IR 4.0 intervention. Improvements were also observed in students' writing and speaking performance, as reflected in higher post-intervention grades. Qualitative findings further indicated positive student attitudes towards the approach, highlighting enhanced engagement, learner autonomy, digital literacy, and the development of transferable soft skills such as collaboration and time management. However, the study also identified several challenges, including unstable internet connectivity, financial constraints, unequal group participation, and uncondusive home learning environments, reflecting broader digital divide issues. Overall, the findings suggest that PBL integrated with IR 4.0 tools constitutes a robust and adaptable pedagogical model for foreign language learning. The study contributes empirical evidence to the growing literature on technology-enhanced PBL and offers implications for instructional design, institutional support, and future research in digitally mediated language education.

Keywords: project-based learning; vocabulary; IR 4.0; Spanish language; teaching and learning

INTRODUCTION

Project-Based Learning (PBL) has been widely recognised as a learner-centred approach that promotes meaningful learning through sustained engagement in purposeful tasks culminating in an authentic product (Blumenfeld et al., 1991; Thomas, 2000). In language education, PBL is often associated with improved learner engagement, autonomy, and opportunities for contextualised language use, particularly when learners must plan, negotiate meaning, and produce communicative artefacts collaboratively. The pedagogical logic of PBL also aligns with constructivist and experiential perspectives, whereby knowledge is strengthened through active construction and repeated use in meaningful contexts (Papert, 1980).

Parallel to this, the shift towards Industry 4.0 (IR 4.0) in higher education has accelerated the adoption of digital tools and platforms that support multimodal learning, online collaboration, and technology-mediated assessment

(Anggraeni, 2018; Maria et al., 2018). In an IR 4.0-oriented learning environment, students are expected not only to acquire disciplinary knowledge but also to develop digital competence, creativity, and collaborative problem-solving skills, capacities that are increasingly central in contemporary higher education (Kowang et al., 2020). When PBL is integrated with IR 4.0 tools (PBL + IR 4.0), the approach may offer a pedagogically coherent model: students learn language through authentic production while simultaneously engaging with digital tools for research, design, editing, and dissemination.

Despite these potentials, empirical research that specifically examines PBL + IR 4.0 in Spanish as a foreign language within Malaysian higher education remains limited. Existing PBL studies in language learning often emphasise broad communicative competence or general learning engagement, with less consistent attention to measurable vocabulary development as a focal outcome, especially when combined with digital production tasks. This gap is important because vocabulary knowledge is a foundational component of language proficiency and is strongly implicated in learners’ ability to perform in both speaking and writing. As argued in earlier scholarship, the breadth and depth of vocabulary substantially shape the quality of language use; limited vocabulary constrains fluency and communicative effectiveness (Tarigan, 1993; Wilkins, 1972).

In the Malaysian university context, Spanish is typically taught as an elective foreign language, and learners often have limited exposure beyond classroom contact hours. Under such conditions, instructional approaches that intensify meaningful vocabulary use, through repeated retrieval, contextualised production, and multimodal reinforcement, are pedagogically desirable. The integration of IR 4.0 tools may further strengthen this process by enabling learners to rehearse, edit, and refine language outputs (e.g., scripts, subtitles, recorded dialogues) while accessing digital resources to verify meanings and usage. However, digital integration also raises practical concerns, including uneven access to stable internet connectivity, financial constraints, and challenges in sustaining effective online collaboration, issues reported during the broader transition to online learning (Adnan & Anwar, 2020; Chung et al., 2020).

Against this backdrop, the present study investigates the appropriateness and effectiveness of implementing a PBL + IR 4.0 approach to enhance Spanish vocabulary mastery among Malaysian university students, while also documenting perceived benefits and constraints from learners’ perspectives. Using a one-group pre–post design with embedded qualitative data, the study examines vocabulary gains alongside changes in performance in writing and speaking tasks linked to a video-based project, complemented by interview and observational evidence on learners’ experiences using IR 4.0 tools.

Accordingly, this study is guided by the following research questions:

1. What are students’ attitudes towards the PBL + IR 4.0 approach in the teaching and learning of Spanish vocabulary?
2. How does the PBL + IR 4.0 approach affect students’ mastery of Spanish vocabulary, writing, and speaking?
3. What benefits do students perceive from implementing PBL + IR 4.0 in a Spanish language course?
4. What challenges do students encounter when implementing PBL + IR 4.0, and what improvements do they suggest for future implementation?

Conceptual Framework of the Study

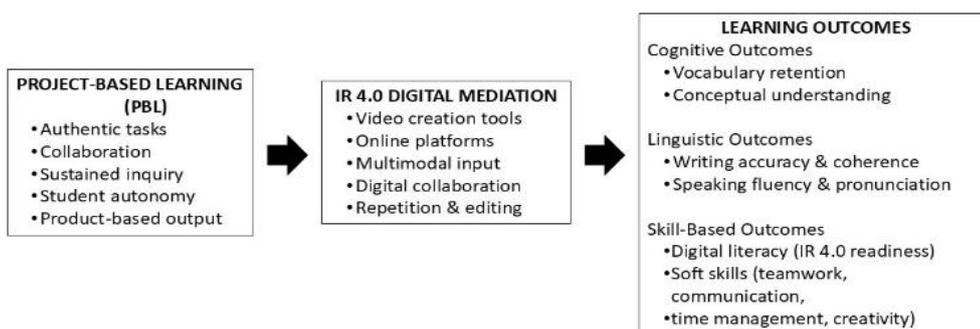


Figure 1. Conceptual framework integrating Project-Based Learning (PBL) and Industry 4.0 digital tools to enhance vocabulary mastery, language skills, and transferable competencies.

This study is guided by a conceptual framework grounded in constructivist and experiential learning theories, which posit that knowledge is actively constructed through meaningful engagement and repeated use in authentic contexts (Papert, 1980). The framework integrates the core principles of Project-Based Learning (PBL) with Industry 4.0 (IR 4.0) digital capacities to explain how vocabulary mastery and related learning outcomes may be enhanced in a foreign language learning environment.

As illustrated in Figure 1, PBL functions as the pedagogical foundation of the intervention. Through authentic tasks, sustained inquiry, collaborative work, learner autonomy, and the production of tangible artefacts, students are required to actively engage with target language input and apply it in purposeful contexts. These principles create conditions that encourage repeated language exposure, negotiation of meaning, and contextualised use of vocabulary.

The integration of IR 4.0 digital tools serves as a mediating layer that amplifies the pedagogical impact of PBL. Digital platforms and applications for scripting, video recording, editing, and online collaboration provide multimodal input and output opportunities, enabling students to repeatedly rehearse, refine, and reflect on their language use. Processes such as repeated pronunciation during recording, repeated listening during editing, and continuous checking of meanings through digital resources reinforce vocabulary retention and deepen linguistic awareness.

The interaction between PBL principles and IR 4.0 digital mediation is expected to produce three interrelated categories of learning outcomes. First, cognitive outcomes include improved vocabulary retention, recall, and conceptual understanding, as learners repeatedly process lexical items in meaningful contexts. Second, linguistic outcomes encompass enhanced writing accuracy, sentence construction, pronunciation, and speaking fluency, supported by iterative scripting and recording processes. Third, skill-based outcomes involve the development of digital literacy and transferable soft skills such as teamwork, communication, time management, creativity, and self-regulation.

This conceptual framework aligns closely with the empirical findings of the study, which demonstrate statistically significant gains in vocabulary scores, improvements in writing and speaking performance, and positive learner perceptions regarding digital competence and soft skills development. At the same time, the framework accommodates contextual constraints, such as access to digital infrastructure and learning environments, which may mediate the effectiveness of PBL + IR 4.0 implementation.

METHODOLOGY

Research Design

This study employed a one-group pre–post quasi-experimental design with embedded qualitative data within a mixed-methods exploratory framework. The quantitative component examined changes in students' Spanish vocabulary performance using pre- and post-tests, as well as writing and speaking assessments linked to a project-based intervention. The qualitative component consisted of semi-structured interviews and classroom observations to provide deeper insights into students' learning experiences, attitudes, and challenges during the implementation of the PBL + IR 4.0 approach. The integration of both datasets enabled a comprehensive evaluation of the effectiveness and pedagogical appropriateness of the intervention.

Participants

The participants for the quantitative phase were 24 undergraduate students majoring in tourism at a public university in Malaysia. All participants were enrolled in a Level 3 Spanish course, a compulsory elective, and had previously completed Level 1 and Level 2 Spanish, indicating comparable foundational knowledge in Spanish vocabulary and grammar. These 24 students provided complete and usable pre- and post-test data and were therefore included in the inferential statistical analysis.

For the qualitative phase, eight students were purposively selected based on their level of engagement, classroom participation, and ability to articulate their learning experiences.

Instruments

Four main instruments were utilised in this study. A researcher-developed vocabulary pre-test and post-test

assessed students' mastery of Spanish vocabulary related to themes such as nature, tourism, and vacations. The test included matching, fill-in-the-blank, translation identification, and sentence-completion items. Content validity was established through expert review by two Spanish language lecturers, and the same instrument was administered before and after the intervention.

Students' writing and speaking skills were assessed through project-embedded tasks. Writing performance was evaluated based on Spanish scripts and storyboards, while speaking performance was assessed using recorded dialogues from the vocabulary videos. A rubric measuring accuracy, vocabulary range, fluency, coherence, and pronunciation was applied. To enhance reliability, two independent Spanish language instructors conducted the assessments, and discrepancies exceeding 10% were resolved through discussion.

Qualitative data were collected using a semi-structured interview protocol focusing on students' attitudes, perceived benefits, challenges, and suggestions for improvement. Interviews were conducted online, audio-recorded, and transcribed verbatim. In addition, structured observations were conducted throughout the project to document collaboration patterns, vocabulary use, digital tool utilisation, problem-solving behaviours, and implementation challenges.

Procedure

The PBL + IR 4.0 intervention was implemented over nine weeks following a structured and scaffolded project sequence. Students were organised into groups and engaged in a series of activities including digital platform setup, project briefing, vocabulary list development, storyboard and script writing, video production, and final submission. Throughout the intervention, students utilised various IR 4.0-aligned digital tools for scripting, recording, editing, and online collaboration. Continuous instructor consultations and weekly digital updates were incorporated to support formative feedback and project monitoring. The intervention concluded with the submission of final video products, reflection activities, and the administration of the post-test.

Data Analysis

Quantitative data were analysed using descriptive and inferential statistics. Means and standard deviations were calculated to compare pre- and post-test vocabulary scores. A paired-sample t-test was conducted to determine the statistical significance of score differences, and Cohen's *d* was calculated to estimate effect size. Changes in the proportion of students achieving higher grades in writing and speaking were examined using pre- and post-intervention percentages.

Qualitative data from interviews and observations were analysed using thematic analysis based on Braun and Clarke's (2006) six-phase framework. Trustworthiness was enhanced through data triangulation, peer debriefing, and member checking to ensure the credibility and accuracy of the qualitative findings.

FINDINGS

This section reports the findings in accordance with the four research questions, namely: (1) students' attitudes towards the PBL + IR 4.0 approach, (2) the impact of the approach on vocabulary, writing, and speaking mastery, (3) the benefits gained through participation, and (4) the challenges encountered during implementation.

Students' Attitudes Towards the PBL + IR 4.0 Approach

Interview data indicate that students held consistently positive attitudes towards the PBL + IR 4.0 approach. The project was perceived as engaging, meaningful, and distinct from conventional classroom-based learning. Students highlighted that the integration of video production and digital platforms encouraged active participation, curiosity, and exploration of new learning strategies.

Participants frequently described the experience as motivating and memorable, noting that it enabled them to take greater ownership of their learning while experimenting with unfamiliar digital tools. Several students emphasised that the project fostered creativity and independence, while simultaneously enhancing their confidence in using technology for academic purposes. Overall, exposure to IR 4.0 tools contributed to a heightened sense of innovation and engagement in Spanish language learning.

Impact on Mastery of Spanish Vocabulary

Findings provide clear evidence that the PBL + IR 4.0 intervention positively influenced students’ Spanish vocabulary mastery. Students consistently reported that repeated engagement with vocabulary during scripting, memorisation, filming, and editing processes strengthened retention and comprehension. Key mechanisms underlying this improvement included repeated pronunciation practice, repeated listening during video editing, continuous translation and meaning verification, sentence construction in Spanish, and active searching for new vocabulary aligned with project themes.

These processes facilitated sustained exposure to target lexical items in meaningful contexts, reinforcing vocabulary learning through multimodal and iterative use.

Pre–Post Vocabulary Test Results

To illustrate the quantitative improvement in vocabulary performance following the intervention, a comparison of pre-test and post-test scores is presented in Figure 1.

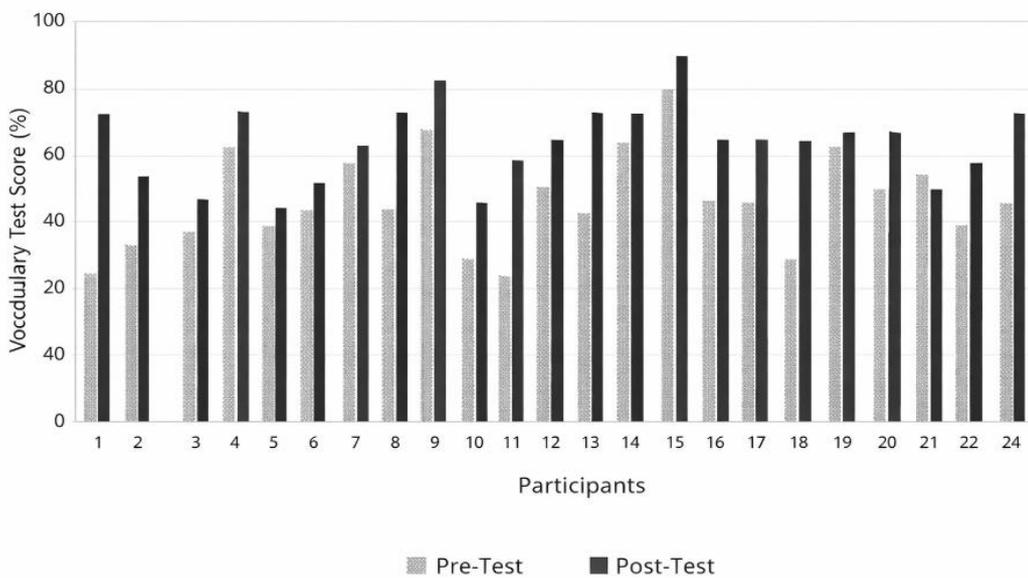


Figure 1: Vocabulary Test Scores of Individual Participants Before and After the PBL + IR 4.0

Quantitative analysis corroborated the qualitative findings. The mean vocabulary score increased from $M = 57.21$, $SD = 18.37$ in the pre-test to $M = 76.67$, $SD = 9.50$ in the post-test. A paired-sample t -test revealed that this improvement was statistically significant, $t(23) = 5.49$, $p < .001$, with a large effect size (Cohen’s $d = 1.12$). As illustrated in Figure 1, the majority of students demonstrated higher post-test scores, indicating a strong and consistent positive effect of the PBL + IR 4.0 approach on vocabulary acquisition.

Improvement in Writing and Speaking Skills

Students also reported noticeable improvements in writing and speaking skills as a result of producing scripts, storyboards, and video recordings entirely in Spanish. Writing development was attributed to repeated drafting and revision of scripts, which enhanced sentence construction, vocabulary usage, grammatical accuracy, and coherence. Speaking improvement was linked to repeated recording and rehearsal, which supported pronunciation refinement, fluency development, and increased confidence.

Students indicated that memorisation of dialogue lines and repeated oral practice contributed to greater ease and accuracy in spoken Spanish.

Writing and Speaking Assessment Results

The improvements in writing and speaking performance are summarised visually in Figure 2.

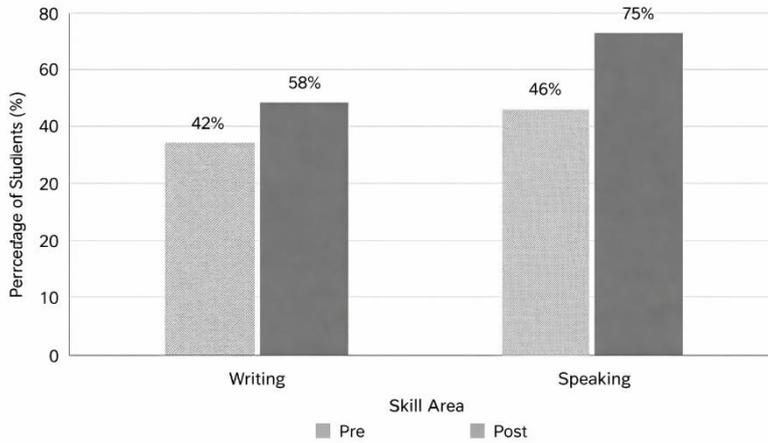


Figure 2: Percentage of students achieving A grades in pre- and post-intervention Spanish writing and speaking tasks.

As shown in Figure 2, the proportion of students obtaining an A increased by 16% in writing and 29% in speaking. These results suggest that integrating IR 4.0 tools within a PBL framework effectively supports the development of productive language skills, particularly through authentic, project-based language use.

Enhancement of Digital Technology Skills

Participation in the project led to substantial gains in students' digital literacy. Students became more proficient in video recording and editing, and more confident in using multiple IR 4.0-aligned platforms such as TikTok, VN, CapCut, Canva, Filmora, iMovie, Google Sites, and Flipsnack. They also developed skills in integrating animations, background music, subtitles, and visual effects to enhance the quality of their digital artefacts.

In addition, students reported improved competence in navigating online collaborative tools, which facilitated coordination, communication, and shared responsibility throughout the project. These findings indicate that the PBL + IR 4.0 approach effectively promotes IR 4.0 readiness alongside language learning.

Development of Soft Skills

The collaborative structure of the project fostered the development of a range of soft skills. Students reported improvements in teamwork and communication as they negotiated roles, resolved disagreements, and coordinated tasks. Leadership skills emerged as group members assumed responsibility for specific aspects of production. Time management was strengthened through deadline-driven tasks, while creativity and critical thinking were stimulated through scriptwriting, storyboard design, and problem-solving during video production.

Students also demonstrated increased responsibility and self-regulation, as individual contributions directly affected group outcomes. Notably, these skills emerged organically through the project process, despite not being explicitly assessed.

Challenges Faced by Students

Despite the positive outcomes, several challenges were identified. Unstable internet connectivity frequently disrupted online discussions and slowed file uploads, limiting effective use of digital tools. Online group discussions were often constrained by reduced social presence, audio delays, limited engagement, and the absence of non-verbal cues. Financial constraints further affected participation, with some students reporting substantial weekly expenditure on mobile data.

Unequal participation among group members occasionally hindered progress and affected group morale. In addition, heavy academic workloads and dense schedules contributed to time management difficulties. These challenges were exacerbated by unconducive home learning environments, including noise, limited private space, family responsibilities, and external disturbances.

DISCUSSION

The purpose of this study was to examine the effectiveness and appropriateness of integrating Project-Based Learning with Industry 4.0 tools (PBL + IR 4.0) in enhancing Spanish vocabulary mastery among Malaysian university students. By triangulating quantitative gains with qualitative perceptions, the discussion below not only confirms the effectiveness of the intervention but also critically interprets *why* it worked, *for whom* it worked best, and *under what constraints* its impact may be uneven.

PBL + IR 4.0 and Vocabulary Learning: Beyond Score Gains

The statistically significant increase in vocabulary scores with a large effect size ($t(23) = 5.49, p < .001, d = 1.12$) suggests that the intervention produced an educationally meaningful improvement in vocabulary mastery. From a constructivist perspective, vocabulary learning was strengthened because lexical items were repeatedly processed and applied through authentic meaning-making activities, rather than memorised in isolation (Papert, 1980). Students' accounts indicate that vocabulary development was embedded in purposeful production, writing scripts, rehearsing dialogue, recording, and editing, thereby enabling deeper lexical processing, repeated retrieval, and contextual reinforcement.

Critically, this mechanism differentiates PBL + IR 4.0 from several common vocabulary teaching approaches. Traditional approaches such as direct instruction, word lists, or drill-based exercises can be efficient for initial exposure and form–meaning mapping, yet they often provide limited opportunities for repeated contextualised output and multimodal reinforcement. In contrast, the PBL + IR 4.0 project required sustained engagement with vocabulary across time (nine weeks) and across modes (spoken rehearsal, visual design, written scripting, and auditory repetition during editing). This extended cycle likely enhanced durable retention by combining intentional learning (explicit searching and checking meanings) with incidental learning (repeated exposure through production). The results therefore align with the broader PBL literature showing that active engagement and contextualised use support vocabulary acquisition more effectively than decontextualised practice alone (Lai, 2021; Muzana et al., 2021; Vergara-Castañeda et al., 2021).

Why the Intervention May Benefit Some Students More Than Others

While the overall trend indicates improvement for most participants, the pattern of gains may not be uniform across the cohort. A critical interpretation is that differential benefits are likely shaped by variation in *learner resources* and *group-level dynamics*. Students with stronger baseline language proficiency or greater confidence in speaking may have benefited more because they could allocate cognitive effort toward refining vocabulary usage and pronunciation rather than struggling with basic sentence construction. Similarly, students with prior digital experience (e.g., familiarity with editing apps, online collaboration) may have progressed faster, allowing more time and mental capacity for language-focused improvement rather than technical troubleshooting.

Group structure may also amplify inequality in outcomes. Well-functioning groups provide peer scaffolding, distributed workload, and frequent opportunities for negotiation of meaning, conditions that accelerate vocabulary uptake and productive practice. Conversely, groups with unequal participation may reduce language practice opportunities for some members (e.g., a small subset writing scripts and editing videos), limiting others' exposure to repeated retrieval and output. In this sense, PBL can be both an enabler and a filter: it rewards engagement, but it can also magnify differences in contribution, leadership, and accountability if monitoring mechanisms are not sufficiently strong. This interpretation is consistent with the finding that some students experienced passive participation among peers, which may have shaped both project quality and individual learning gains.

Productive Skills Development: Authentic Output with Iterative Refinement

The improvement in writing and speaking aligns with the project's design, which naturally embedded productive language demands into the learning process. Writing improved through iterative scripting and revision, which required students to organise ideas, select vocabulary appropriately, and attend to grammatical accuracy. Speaking improved through repeated oral rehearsal and recording, allowing students to notice pronunciation gaps and self-correct over multiple attempts. This cycle resonates with the view that meaningful output and repeated practice contribute to language development, particularly when learners must produce intelligible and

audience-oriented speech (Krashen, 1982). The increase in high grades for writing and speaking tasks further supports the claim that the intervention strengthened performance beyond vocabulary recognition, extending into productive competence. Similar outcomes have been reported in digital-storytelling and video-based PBL studies, where artefact production encourages multiple rounds of drafting, rehearsal, and performance refinement (Du et al., 2022; Imaz, 2021).

IR 4.0 Mediation: Digital Literacy as Both Outcome and Condition

Students' reported gains in digital literacy reflect the intended IR 4.0 orientation of the project, particularly the development of technology-enabled creativity and problem-solving (Maria et al., 2018). However, a deeper reading suggests that digital tools functioned not only as an outcome but also as a *mediating condition* that shaped the quality of language learning. When students could access stable platforms and collaborate effectively, IR 4.0 tools amplified PBL benefits by enabling multimodal reinforcement, rapid feedback cycles, and repeated rehearsal through editing. Conversely, when access was unstable or costly, the same tools became barriers that increased cognitive load and reduced time-on-task for language learning. This dual role highlights that technology integration is not automatically beneficial; its pedagogical value depends on infrastructural reliability and equitable access.

Digital Divide as a Layered Constraint, not a Single “Internet Problem”

The challenges reported, unstable connectivity, financial strain, limited conducive learning space, and reduced quality of online collaboration, reflect structural constraints typical of pandemic-era learning contexts (Adnan & Anwar, 2020; Chung et al., 2020). Importantly, these constraints should be interpreted as a layered digital divide rather than a single technical problem. The divide includes (1) *access divide* (connectivity and device availability), (2) *affordability divide* (ongoing mobile data expenditure), and (3) *learning environment divide* (home conditions that limit sustained participation and focus). These layers interact: students with unstable internet may contribute less during synchronous meetings; those who rely on mobile data may limit video uploads or reduce participation frequency; those in crowded homes may struggle with recording quality and rehearsal time. Consequently, the intervention's effectiveness is likely moderated by socio-economic and contextual factors, which can lead to unequal learning opportunities even within the same classroom.

Therefore, while PBL + IR 4.0 appears pedagogically promising, its scalability requires institutional strategies that reduce structural inequities, such as improved campus connectivity support, flexible submission formats, and assessment designs that capture individual contribution to prevent unequal group participation from translating into unequal learning gains.

LIMITATIONS

Several limitations of this study should be acknowledged. First, the study employed a one-group pre–post quasi-experimental design without a control or comparison group. Although statistically significant gains were observed, the absence of a control group limits the ability to attribute improvements exclusively to the PBL + IR 4.0 intervention, as other factors such as independent learning, prior exposure to Spanish, or maturation effects may have influenced the outcomes.

Second, the sample size was relatively modest and drawn from a single public university context. While 40 students participated in the intervention, only 24 students provided complete matched pre- and post-test data for inferential analysis. This reduces statistical power and limits the generalisability of the findings to broader student populations or institutional settings.

Third, although writing and speaking assessments were evaluated by two independent raters to enhance scoring reliability, the possibility of grading bias cannot be entirely ruled out, particularly given the subjective nature of performance-based language assessment. While discrepancies were resolved through discussion, more rigorous inter-rater reliability statistics could strengthen future analyses.

Fourth, students' attitudes, perceived benefits, digital literacy development, and soft skills gains were primarily measured through self-reported interview data and observational evidence. As such, these findings are interpretive and may be influenced by social desirability bias or participants' subjective perceptions. The absence of standardised instruments for measuring digital literacy and soft skills limits the objectivity of these outcomes.

Finally, the study was conducted during the COVID-19 pandemic, with data collection taking place fully online. Contextual constraints such as unstable internet access, financial strain, emotional fatigue, and unconducive home learning environments may have shaped students' learning experiences and perceptions of the PBL + IR 4.0 approach. These pandemic-specific conditions should be considered when interpreting the findings, as the effectiveness of the intervention may differ in post-pandemic or face-to-face instructional contexts.

IMPLICATIONS

Theoretical Implications

This study advances theoretical understandings of Project-Based Learning (PBL) and digital pedagogy by demonstrating how the integration of PBL with Industry 4.0 (IR 4.0) digital tools functions as an effective mechanism for vocabulary development in foreign language learning. Grounded in constructivist and experiential learning theories, the findings provide empirical support for the claim that repeated, meaningful, and multimodal engagement with lexical items, through scripting, recording, editing, and collaborative negotiation, enhances vocabulary retention and depth of processing.

More specifically, the statistically significant gains and large effect size observed in this study position PBL + IR 4.0 as more than a motivational or engagement-oriented approach; rather, it operates as a cognitively robust pedagogical model that facilitates sustained lexical exposure, rehearsal, and contextualised use. By linking pedagogical design (PBL), digital mediation (IR 4.0 tools), and measurable linguistic outcomes, this study contributes to the relatively limited body of research on technology-enhanced vocabulary acquisition in Spanish as a foreign language, particularly within Southeast Asian higher education contexts.

Importantly, the findings suggest that vocabulary learning in digitally mediated PBL environments is not incidental but structurally embedded within iterative production processes, thereby extending existing PBL theories that have traditionally focused on general communicative competence rather than specific lexical outcomes.

Practical Implications for Teaching and Learning

From a pedagogical perspective, the findings indicate that integrating PBL with IR 4.0 tools is a feasible and effective strategy for enhancing vocabulary mastery as well as productive language skills in university-level foreign language courses. The requirement for students to produce authentic digital artefacts, such as video-based projects, encourages deeper cognitive engagement with vocabulary through repeated use, revision, and reflection, rather than surface-level memorisation.

The results further suggest that video-based PBL tasks support writing development through iterative script drafting and revision, while simultaneously enhancing speaking fluency and pronunciation accuracy through repeated recording and self-monitoring. These processes align closely with principles of meaningful output and form-focused attention, making PBL + IR 4.0 particularly suitable for vocabulary-driven language courses.

However, the effectiveness of this approach depends on appropriate instructional scaffolding. Regular progress monitoring, structured milestones (e.g., storyboard development), and early exposure to essential digital tools are necessary to prevent cognitive overload and uneven participation. Additionally, assessment rubrics should explicitly incorporate criteria related to collaboration and individual contribution to mitigate the risk of passive group members and to promote accountability.

Overall, the findings support the adoption of PBL + IR 4.0 as a data-informed instructional approach that balances linguistic development, digital literacy, and transferable skills, provided that pedagogical design is carefully aligned with learning objectives and learner readiness.

Policy and Institutional Implications

At the institutional and policy level, the findings highlight critical structural conditions that influence the effectiveness of digitally mediated PBL implementation. While PBL + IR 4.0 offers substantial pedagogical benefits, its success is contingent upon equitable access to digital infrastructure. Persistent issues related to unstable internet connectivity, high data costs, and unconducive home learning environments underscore the

continuing digital divide among university students, particularly in post-pandemic blended and online learning contexts.

Universities are therefore encouraged to prioritise digital equity by providing subsidised or free high-speed internet access, improving campus-wide Wi-Fi infrastructure, and ensuring access to shared digital facilities such as computer laboratories for project-based coursework. Institutional funding mechanisms may also be required to support digital project-based assignments so that financial constraints do not disproportionately disadvantage certain student groups.

In addition, professional development programmes should be strengthened to equip lecturers with competencies in IR 4.0-oriented pedagogy, digital assessment literacy, and the management of online collaborative learning. At the curriculum level, the integration of PBL + IR 4.0 should be formally embedded within language programme frameworks as part of broader efforts to cultivate 21st-century skills, digital fluency, and learner autonomy in higher education.

CONCLUSION

This study contributes to the growing body of research on project-based and digitally mediated language learning by advancing a pedagogical model that integrates Project-Based Learning (PBL) with Industry 4.0 digital tools in foreign language education. Grounded in constructivist and experiential learning theories, the PBL + IR 4.0 framework demonstrates how authentic, technology-mediated tasks can create conditions for sustained lexical engagement, multimodal reinforcement, and meaningful language use.

Beyond vocabulary development, the findings highlight the broader pedagogical value of PBL + IR 4.0 in supporting integrated language skills, digital literacy, and transferable competencies essential for 21st-century learning. Importantly, the study illustrates that language learning outcomes are shaped not only by instructional design but also by contextual and infrastructural conditions, underscoring the need to view digital pedagogy through an equity-informed lens.

While the study was conducted within the context of Spanish vocabulary learning during the COVID-19 pandemic, the proposed framework has relevance beyond this specific setting. The principles underpinning PBL + IR 4.0, authentic task design, learner autonomy, collaborative knowledge construction, and digital mediation, are transferable to other foreign languages, language components (e.g., grammar, pragmatics, discourse skills), and post-pandemic instructional contexts, including blended and face-to-face environments.

Future research should build on this work by employing comparative or experimental designs, extending implementation across multiple institutions, and incorporating longitudinal measures to examine sustained language development. Further investigation into differentiated learning outcomes among student groups, the role of digital access and participation patterns, and the scalability of PBL + IR 4.0 within diverse educational contexts would deepen understanding of its pedagogical potential. Collectively, such efforts would strengthen the evidence base for PBL + IR 4.0 as a robust and adaptable approach to foreign language education in higher education.

Ethical Considerations

This study involved minimal-risk educational research conducted in a normal university classroom setting. Although no formal ethical approval was obtained from an institutional review board, the research adhered to ethical principles of voluntary participation, informed consent, privacy, and confidentiality. Prior to data collection, all participants were clearly informed about the purpose of the study, the types of data to be collected, and their rights as participants, including the right to withdraw at any time without academic consequences. Written informed consent was obtained from all students. All collected data were stored securely in password-protected digital files accessible only to the research team.

Conflict Of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets generated and analyzed during the current study are not publicly available due to confidentiality agreements with participants.

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REFERENCES

1. Adnan, M., & Anwar, K. (2020). Online learning amid the COVID-19 pandemic: Students' perspectives. *Journal of Pedagogical Sociology and Psychology*, 2(1), 45–51.
2. Ajmain @ Jima'ain, M. T., Fatin Nabilah, M., Khadijah, A., & Aminuddin Hehsan, H. (2020). Penerokaan terhadap pengetahuan yang digunakan oleh guru inovatif pendidikan Islam untuk menghasilkan inovasi pengajaran. *Akademika*, 93(2), 1215–1225.
3. Anggraeni, C. W. (2018). Promoting Education 4.0 in English for survival class: What are the challenges? *Metathesis: Journal of English Language, Literature, and Teaching*, 2(1), 12–23.
4. Anđelković, J., Meršnik, M., & Jović, J. (2022). Project-based translation of Wikipedia articles in a tertiary ESP context: Planning, execution and lessons learnt. *ESP Today*, 10(1), 123–144. <https://doi.org/10.18485/ESPTODAY.2022.10.1.6>
5. Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3–4), 369–398.
6. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
7. Chung, E., Noor, N. M., & Mathew, V. N. (2020). Are you ready? An assessment of online learning readiness among university students. *International Journal of Academic Research in Business and Social Sciences*, 10(5), 971–989.
8. Du, X., Lundberg, A., Ayari, M. A., Naji, K. K., & Hawari, A. (2022). Examining engineering students' perceptions of learner agency enactment in problem- and project-based learning using Q methodology. *Journal of Engineering Education*, 111(1), 111–136. <https://doi.org/10.1002/jee.20430>
9. Haji Gapor, A. L., & Yeop, M. A. (2013). Kesan pendekatan pembelajaran berasaskan projek berteraskan teknologi terhadap pencapaian dan penerimaan pelajar. *Jurnal Bitara*.
10. Imaz, J. I. (2021). "How has your city changed?" Using project-based learning to teach sociology of education. *Education and Urban Society*. <https://doi.org/10.1177/00131245211004552>
11. Kowang, T. O., Bakry, M. F., Hee, O. C., Fei, G. C., Yew, L. K., Saadon, M. S. I., & Long, C. S. (2020). Industry 4.0 competencies among lecturers of higher learning institution in Malaysia. *International Journal of Evaluation and Research in Education*, 9(2), 303–310. <https://doi.org/10.11591/ijere.v9i2.20520>
12. Krashen, S. D. (1982). *Principles and practice in second language acquisition*. Pergamon.
13. Kumar, J. A. (2021). Educational chatbots for project-based learning: Investigating learning outcomes for a team-based design course. *International Journal of Educational Technology in Higher Education*, 18(1). <https://doi.org/10.1186/s41239-021-00302-w>
14. Lai, C. L. (2021). Effects of the group-regulation promotion approach on students' individual and collaborative learning performance, perceptions of regulation and regulation behaviours in project-based tasks. *British Journal of Educational Technology*, 52(6), 2278–2298. <https://doi.org/10.1111/bjet.13138>
15. Mahsan, I. P. (2018). Aplikasi pembelajaran berasaskan projek bidang seni digital: Kajian kes di lima buah institusi pengajian tinggi di Malaysia (Doctoral dissertation, Universiti Pendidikan Sultan Idris).
16. Makkonen, T., Tirri, K., & Lavonen, J. (2021). Engagement in learning physics through project-based learning: A case study of gifted Finnish upper-secondary-level students. *Journal of Advanced Academics*, 32(4), 501–532. <https://doi.org/10.1177/1932202X211018644>
17. Maria, M., Shahbodin, F., & Pee, N. C. (2018). Malaysian higher education system towards Industry 4.0 – Current trends overview. *AIP Conference Proceedings*, 2016(1), 020081.

18. Mioduser, D., & Betzer, N. (2003). The contribution of project-based learning to high achievers' acquisition of technological knowledge and skills. *International Journal of Technology and Design Education*, 13, 219–234.
19. Mohd Aderi Che Noh, Normurni Mohamad, Adibah Hasanah Abd Halim, & Absha Atiah Abu Bakar. (2018). Pelaksanaan kaedah pembelajaran berasaskan projek dalam pengajaran dan pembelajaran Kaedah Fiqh. *The Journal of Quran Sunnah Education and Special Needs*.
20. Mohd Saad, H. (2018). Pembelajaran berasaskan projek (PBL): Impak pembudayaan 4C's. Dalam Seminar Nasional Pengurusan dan Kepimpinan Pendidikan ke-25 (pp. xx–xx), IAB Bandar Enstek, Perak, Malaysia.
21. Muzana, S. R., Jumadi, Wilujeng, I., Yanto, B. E., & Mustamin, A. A. (2021). E-STEM project-based learning in teaching science to increase ICT literacy and problem solving. *International Journal of Evaluation and Research in Education*, 10(4), 1386–1394. <https://doi.org/10.11591/ijere.v10i4.21942>
22. Papert, S. (1980). *Mindstorms: Children, computers and powerful ideas*. Basic Books.
23. Rashid, W. H. W., Kob, C. G. C., & Abdullah, A. S. (2020). Keberkesanan pembelajaran berasaskan projek terhadap motivasi intrinsik dalam subjek Projek Tahun Akhir 1 (PTA1) di Kolej Vokasional Slim River.
24. Salmela, R., Lehtonen, M., Garusi, S., & Bertram, R. (2021). Lexize: A test to quickly assess vocabulary knowledge in Finnish. *Scandinavian Journal of Psychology*, 62(6), 806–819. <https://doi.org/10.1111/sjop.12768>
25. Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, 83(2), 39–43. <https://doi.org/10.1080/00098650903505415>
26. Tarigan, H. G. (1993). *Berbicara sebagai suatu keterampilan berbahasa*. Angkasa.
27. Thomas, J. W. (2000). A review of project-based learning. Buck Institute for Education. http://www.bie.org/research/study/review_of_project_based_learning_2000/
28. Twinkl. (2022, February 12). What are literacy skills? <https://www.twinkl.com/teaching-wiki/literacy-skills>
29. Vergara-Castañeda, A., Chávez-Miyauchi, T. E., Benítez-Rico, A., & Ogando-Justo, A. B. (2021). Implementing project-based learning as an effective alternative approach for chemistry practical courses online. *Journal of Chemical Education*, 98(11), 3502–3508. <https://doi.org/10.1021/acs.jchemed.1c00379>
30. William H. Kilpatrick (1871–1965). (n.d.). StateUniversity.com. <https://education.stateuniversity.com/pages/2147/Kilpatrick-William-H-1871-1965.html>
31. Wilkins, D. A. (1972). *Linguistics in language teaching*. Edward Arnold.
32. Yang, Y., Zhang, Y., Xiong, X., Zhang, W., Chen, W., & Ge, S. (2021). From lab scale to mass production: A project-based learning on the preparation of (S)-epichlorohydrin for enhancing college student engineering practical abilities. *Journal of Chemical Education*, 98(12), 3804–3812. <https://doi.org/10.1021/acs.jchemed.1c00483>
33. Yusof, M. N. M., Musta'amal, A. H., Audu, R., & Ismail, N. S. (2015). Implementation of project-based learning (PjBL) at a Malaysian polytechnic: A preliminary study. Dalam *Proceedings of INTCESS15 – 2nd International Conference on Education and Social Sciences*, Turkey.
34. Zulfa, Z., Nusi, A., Ananda, A., Efi, A., & Pernantah, P. S. (2022). Using simulation on project-based learning in Minangkabau culture subject. *International Journal of Instruction*, 15(1), 311–326. <https://doi.org/10.29333/iji.2022.15118a>