

PAPER

Student Engagement and Accuracy in AR-Supported Grammar Learning: An Exploratory Study in an EFL Context

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ABSTRACT

This exploratory study examines the use of augmented reality (AR) to support the learning of English conditional forms, a grammatical area that is traditionally challenging for learners in secondary education. However, evidence of AR's efficacy for grammar gains in authentic classroom settings is still emerging and often limited by small-scale, descriptive studies. As part of an exploratory intervention, a convenience sample of 92 fourth-year secondary students (aged 14–16) across four classes participated in a one-month period where regular instruction was supplemented with AR activities authored in Onirix and delivered on tablets. A mixed-methods design combined quantitative pre- and post-test results with qualitative data from student questionnaires, classroom observations, and teacher feedback. Descriptive and inferential analyses indicated observable gains in targeted grammatical forms during the instructional unit, with an average accuracy increase of 21 percentage points from pre- to post-test. Inferential testing showed statistically significant differences for the zero/first and second conditional scores, whereas gains for the third conditional were more limited. Students reported high engagement (82%) and perceived the AR activities as useful for understanding meaning (87%), while teachers observed increased motivation and collaborative learning. Although limited by the convenience sampling and the pre-experimental one-group design, the findings suggest that AR-supported activities may provide a promising complementary approach to grammar instruction in secondary EFL (English as a Foreign Language) classrooms, demonstrating the pedagogical potential of AR authoring tools.

KEYWORDS

augmented reality (AR), mobile learning, interactive mobile technology, tablet-based AR, English grammar, conditionals, secondary education, English as a Foreign Language (EFL)

1 INTRODUCTION

Over the last decade, immersive technologies have moved from research labs to classrooms, prompting new opportunities to support motivation, engagement,

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and learning. In language education, augmented reality (AR) has been utilized to simulate authentic scenarios that allow learners to experiment with the target language in a low-stakes, highly interactive environment [2], [21]. Meta-analyses report positive effects of AR/VR on motivation and outcomes, though results vary by context [4], [14]. Earlier work has also documented effects on cognitive and linguistic development in immersive environments [5]. Recent bibliometric analyses have also highlighted the global expansion of mobile learning in education, reinforcing the relevance of AR-based interventions within broader mobile-assisted learning frameworks [25].

Although much of the early work emphasized vocabulary and speaking [4], [7] and affective benefits such as reduced foreign-language anxiety [16], comparatively fewer classroom studies have looked at the role of immersive technologies in the teaching of complex grammar in secondary education [7], [8]. From a pedagogical standpoint, an AR-enhanced approach aligns with experiential learning and situated cognition [13]. In addition, several studies suggest immersive environments can lower affective barriers, encouraging participation and risk-taking in the target language [13]. Recent work has also highlighted the importance of teacher preparation and digital competence for effective AR integration in language education [3], [24].

Despite this promise, practical constraints remain: hardware access, preparation time, and the risk that novelty eclipses learning goals. Moreover, evidence on grammar gains in real secondary classrooms is still emerging and often based on small samples with descriptive analyses only. This report documents an exploratory AR classroom intervention with Spanish secondary students, describing implementation, outcomes, and perceptions. The goals were to (a) describe the implementation in an authentic classroom, (b) report descriptive outcomes on targeted grammar items, and (c) summarize student and teacher perceptions. By focusing on concise, classroom-relevant evidence, the study seeks to inform teachers and researchers interested in integrating immersive tools into grammar instruction in secondary education. Although the study is situated in a specific educational context in Spain, the instructional design and implementation details are reported with the aim of informing similar classroom applications of AR-supported grammar learning in other EFL settings.

In summary, the integration of AR into secondary education has received limited attention with respect to grammar teaching, despite the growing body of research on immersive technologies. This study therefore reports an exploratory classroom-based intervention examining how AR-supported activities can be integrated into the teaching of English conditionals, a set of structures that are traditionally difficult for learners. By situating grammar within meaningful contexts, the study explores whether AR-supported activities may be associated with accuracy gains and student engagement in secondary school learners. In addition to reporting learning outcomes, the study contributes a detailed description of a classroom-based AR implementation for grammar instruction, providing practical insights that may inform future experimental research in mobile-assisted language learning.

2 MATERIALS AND METHODS

2.1 Sample and context

The intervention took place in a Spanish secondary school with a convenience sample of 92 4th-year ESO students (aged 14–16) across four intact classes.

Classes followed the regular curriculum; the school did not allow random assignment, so the study was designed as a classroom-based exploratory project. The study was conducted as part of the EDUC-AR research project (ref. CIAICO/2022/079) funded by the Generalitat Valenciana GVA, which investigates the educational applications of augmented reality in language learning contexts.

2.2 Design and instruments

A mixed-methods approach was used within a one-group pretest–posttest classroom design, which should be considered a pre-experimental exploratory study without a control group. This design was adopted due to practical constraints in the school setting and the exploratory aim of documenting the implementation of AR-supported activities in an authentic classroom context. Because the study did not include a control group, the design does not allow causal attribution of the observed learning gains specifically to the AR intervention. Consequently, the results should be interpreted as exploratory classroom observations rather than experimental evidence of effectiveness.

The grammar test sampled zero, first, second, and third conditional forms through short items targeting both form and meaning. The student questionnaire gathered perceptions of motivation, usefulness, and ease of use; informal teacher feedback captured feasibility, observed engagement, and perceived learning. The grammar test contained multiple-choice and short-production items that targeted the three main types of conditionals. This format was chosen in order to combine recognition and recall while keeping the test feasible within a classroom setting. The questionnaire included a set of five Likert-scale items and two open-ended questions, which were designed to elicit both quantitative and qualitative insights into students' perceptions. Items were reviewed by the classroom teacher to ensure alignment with the curriculum and clarity of instructions before administration. Observation focused on patterns of collaboration, time on task, and student engagement, providing triangulation for the test and questionnaire data. The grammar test was a researcher-developed classroom assessment designed specifically for this study in order to evaluate students' understanding of English conditional structures aligned with the curricular objectives of the instructional unit. Items were designed to capture both recognition and production aspects of conditional forms within short contextualized prompts.

2.3 AR materials (Onirix software)

Immersive activities were authored in Onirix (a web-based AR authoring platform) and delivered on iPads/tablets as AR scenes anchored to printed markers and classroom surfaces. Each conditional was tied to a contextualized mini-scenario designed to make the meaning salient: e.g., a kitchen scene for the zero conditional (“If you heat water, it boils”), realistic options and consequences for the first conditional, imagined or aspirational scenarios for the second conditional (e.g., being rich), and counterfactual storylines (e.g., “If the dinosaurs had survived...”) to introduce the third conditional. Scenes included hotspots and prompts that required learners to read, listen, and manipulate elements before producing target forms. Example AR lesson scenes are shown in Figure 1.

2.4 Procedure

During a one-month intervention, conventional instruction was supplemented with brief AR sessions integrated into the regular curriculum. Each instructional cycle followed a consistent sequence: (1) a short review of target grammatical forms and their meanings; (2) guided exploration of AR scenes in small groups (2–3 students per device); (3) structured practice activities requiring identification of conditional components and completion of prompts; and (4) brief consolidation tasks. A grammar pre-test was administered prior to the intervention, and a post-test was conducted after the AR-enhanced lessons within the same instructional unit. Classroom observations were systematically documented by the researcher, and the teacher provided a written reflective report at the conclusion of the unit.

2.5 Analysis

Pre- and post-intervention item-level percentages and aggregate scores were first calculated for each conditional focus. To examine whether the observed pre–post differences in grammar scores were statistically significant, inferential analyses were conducted on the available raw test scores. Because the pre- and post-test data were anonymized and the number of respondents differed slightly across measurement points, an individually paired analysis could not be conducted reliably. Therefore, Mann–Whitney U tests, a non-parametric procedure for independent samples, were used to compare pre- and post-test score distributions for each conditional focus. Effect sizes were calculated using the *r* index and interpreted according to conventional benchmarks (0.10 = small, 0.30 = medium, 0.50 = large). Questionnaire responses were analyzed descriptively, and qualitative data from classroom observations and teacher feedback were coded thematically by both authors, with discrepancies resolved through discussion and consensus.

3 RESULTS

Grammar Outcomes and Inferential Analysis Across the full sample (N = 92), descriptive analyses showed observable pre–post gains on the targeted items during the instructional unit (refer to Table 1). Averaged across the four conditional foci, overall accuracy increased by 21 percentage points from pre-test to post-test ($M = 62.3\%$ vs. 83.4%), with the largest gains observed for first and second conditionals. To examine whether these differences were statistically significant, Mann–Whitney U tests were conducted on the available raw scores for each conditional focus. The inferential results are presented in Table 2. For the first conditional, accuracy increased from 66.7% to 93.3% (+26.6 pp), showing a clear descriptive gain during the instructional unit. For the second conditional, gains were observed both for context comprehension (75.9% → 96.0%, +20.1 pp) and for a structure-focused prompt (82.8% → 100.0%, +17.2 pp). The latter suggests a potential ceiling effect at post-test; future iterations may require more discriminating items to avoid saturation near 100%. This ceiling effect suggests that the item may have been insufficiently discriminative at higher proficiency levels, limiting its ability to capture additional learning gains beyond a certain threshold. The third conditional, typically the most demanding due to its counterfactual/time-layered semantics, improved from 23.8% to 44.4% (+20.6 pp). Although the absolute post-test level remained

comparatively low, the relative gain implies that brief exposure within meaningful contexts can begin to shift recognition and identification for this target.

Patterns were consistent across the four intact classes, with each group showing the same rank order of difficulty (third > first/second) and the same direction of change from pre to post. Informal error reviews also showed qualitative shifts: several learners who initially produced L1-influenced forms typical of Spanish-speaking learners of English [1] (e.g., “If I will study, I will pass”) produced more target-like constructions in the post-test, especially for the first and second conditionals. This aligns with classroom observations in which students referenced scene visuals to justify their choices, using situational cues as scaffolds to connect form and meaning.

Taken together, the results indicate observable improvements in conditional grammar during the instructional unit in which AR-supported activities were implemented, most strongly for first and second conditionals, and to a lesser extent for third conditional identification within the time available. Given the descriptive design and the small item set, these findings should be interpreted cautiously; nevertheless, the observed gains, the near-ceiling performance on one second-conditional item, and the consistent trends across classes suggest that the approach is instructionally promising.

3.1 Student perceptions

Questionnaire responses indicated high engagement and perceived usefulness of the AR activities for making grammatical meanings salient. Open-ended comments frequently referenced collaboration and interactivity as supports for attention and persistence. Overall, students consistently reported that AR helped them to understand grammar in a more concrete way. In their open-ended responses, many learners expressed that the immersive activities made grammar “visible” and “easier to apply in real situations.” This suggests that the novelty of AR was not perceived merely as entertainment but as a genuine aid to comprehension. Importantly, some students emphasized that the collaborative tasks fostered peer learning, since they could discuss conditional forms while interacting with the AR scenes.

On the Likert-scale items, 87% of students either “agreed” or “strongly agreed” that AR helped them focus on the meaning of conditionals, while 82% rated the activities as more engaging than traditional grammar exercises. Open-ended responses highlighted recurring themes such as “seeing grammar in action” and “remembering rules more easily.” One learner explained that the AR kitchen task “made the zero conditional feel real, not just a rule in the book,” while another noted that “working in pairs made it easier to notice mistakes and correct them.”

3.2 Teacher feedback and observations

The teachers reported increased motivation and active participation during AR phases and noted manageable logistics with small-group device use. Observation notes documented peer discussion of clause structure and reference to scene visuals when justifying choices.

Additionally, teachers emphasized that the AR lessons not only increased participation but also altered classroom dynamics: quieter students were more willing to speak when prompted by on-screen scenarios, while stronger students often took on facilitator roles. Observations confirmed that learners frequently pointed at the

AR scenes to justify their grammatical choices, using the visuals as scaffolds for metalinguistic talk. Compared with non-AR lessons, peer-to-peer exchanges were more frequent and extended, with students negotiating conditional structures collaboratively. Teachers emphasized that the implementation of AR involved only modest preparation and was manageable with two to three devices per group, a setup that reduced classroom disruption and supported lesson continuity.

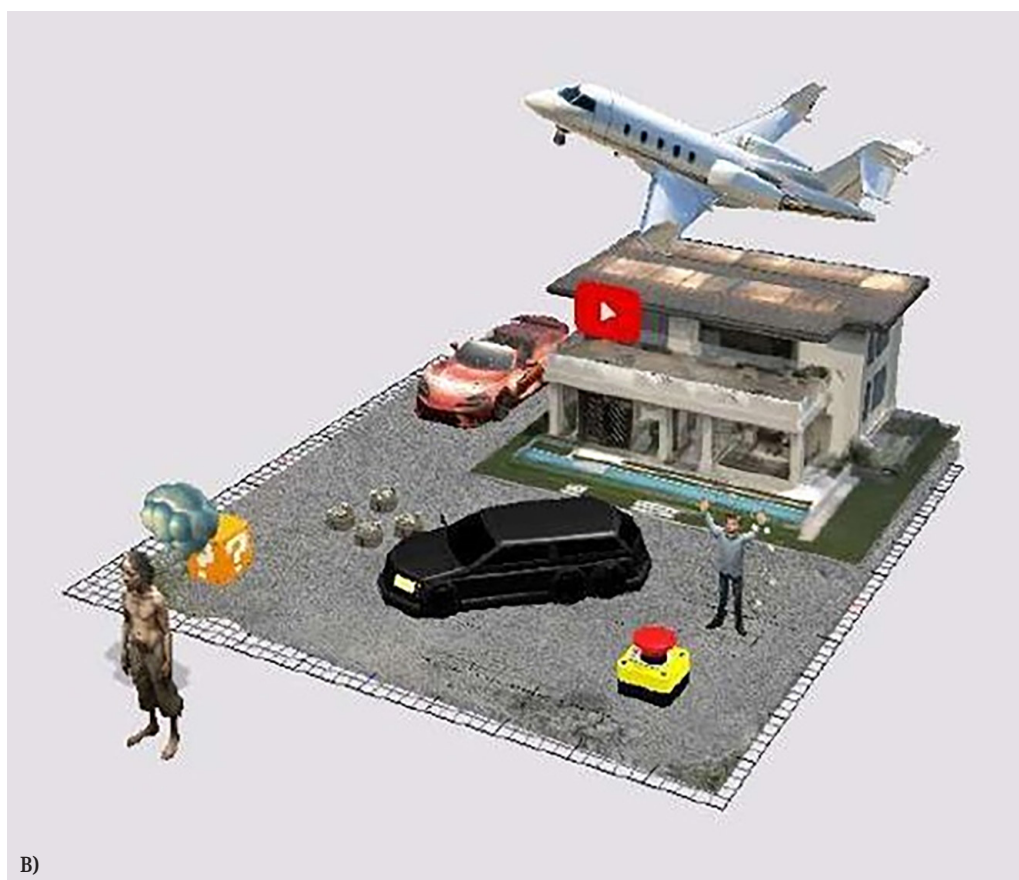
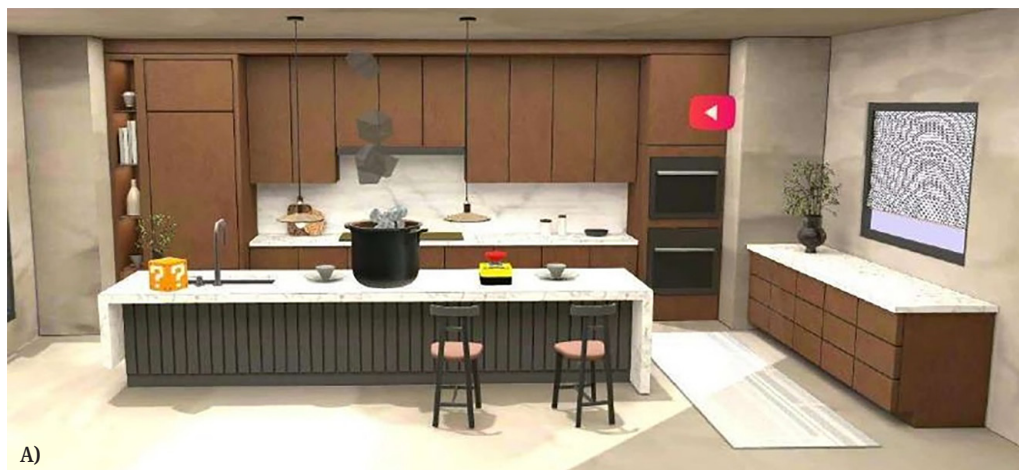


Fig. 1. Screenshots of AR-based grammar lessons. (A) Kitchen scene for the zero conditional (“If you heat water, it boils”). (B) Someone thinking about being rich and what they would buy, second conditional (If I were rich I would buy ...).

Table 1. Descriptive pre- and post-test percentages on selected conditional items

Target	Item Focus	Pre (%)	Post (%)
Zero/First conditional	Correct response (form/meaning)	66.7	93.3
Second conditional	Context comprehension	75.9	96.0
Second conditional	Structure-focused item	82.8	100.0
Third conditional	Identification	23.8	44.4

Note: Values are descriptive and illustrative of the main trends reported in the text.

Table 2. Mann–Whitney U test results for pre-/post-test grammar score blocks

Conditional Focus	Pre-test n	Post-test n	Pre-test M (SD)	Post-test M (SD)	U	p	Effect Size (r)
Zero/First conditionals	21	17	2.43 (0.81)	3.82 (0.53)	27.5	<.001	.71
Second conditional	29	25	3.21 (1.11)	3.96 (0.20)	171.0	<.001	.54
Third conditional	28	22	2.07 (0.66)	2.00 (0.62)	277.5	.535	.09

Notes: Mann–Whitney U tests were used because the anonymized pre- and post-test datasets could not be reliably paired at the individual level. Validity varied across conditional focuses according to the availability of raw scores for each test block. Table 2 reports inferential comparisons based on broader grammar score blocks derived from the raw test data; these blocks do not correspond one-to-one to the illustrative item-level percentages shown in Table 1. Effect size r was interpreted as small (.10), medium (.30), and large (.50). Sample sizes vary due to missing data across test blocks.

The inferential analysis showed statistically significant differences between pre- and post-test scores for the zero/first conditional block and for the second conditional, with large and medium effect sizes, respectively. By contrast, the difference for the third conditional was not statistically significant. These results reinforce the descriptive patterns reported above while remaining consistent with the exploratory and non-causal nature of the study design.

4 DISCUSSION

This exploratory classroom study provides preliminary insights into how AR-supported activities may complement conventional instruction in the teaching of English conditionals in secondary education. Learners demonstrated stronger gains for first and second conditionals, with more modest—yet still positive—improvement on third conditionals. These outcomes echo prior reports that immersive environments can enhance engagement and lower affective barriers to participation [4], [16], [18], [27]. From a pedagogical standpoint, the findings reinforce the argument for experiential and context-rich approaches to grammar instruction [10], [15], [26], particularly for structures such as conditionals that often present challenges in form–meaning mapping. The inferential results are broadly consistent with the descriptive patterns observed in the data; however, given the pre-experimental design and the absence of a control group, statistical significance should not be interpreted as evidence of causal effectiveness. Beyond the learning outcomes reported here, the study contributes a documented example of how tablet-based AR authoring tools can be integrated into regular EFL instruction, which may serve as a reference

point for future, more controlled studies examining the effectiveness of immersive technologies in grammar learning.

A notable strength of the intervention was its feasibility: authoring with Onirix and deploying on tablets proved implementable in a regular classroom setting, without the cost or logistical barriers of head-mounted displays. This aligns with studies stressing the importance of digital competence and teacher readiness in successful AR integration [3], [24]. Teachers in this study reported that AR integration was manageable with small-group device sharing, suggesting that even resource-constrained schools could experiment with lightweight AR. Such practicality is important in contexts where large-scale adoption is often hindered by infrastructure or training demands [12]. By describing the technological setup, instructional sequence, and classroom organization in detail, the study aims to provide insights that may be transferable to comparable EFL learning contexts beyond the specific setting of this research.

Pedagogically, the results point to AR's potential as a complementary tool rather than a replacement for explicit grammar instruction. By situating abstract structures in tangible, interactive scenarios, AR appears to lower barriers for learners who struggle with purely rule-based explanations. This supports earlier findings that immersive tasks can benefit learners with diverse proficiency levels and may serve as a mechanism for differentiated instruction [6], [9], [17]. The motivational dimension is also notable: immersive, collaborative activities appeared to sustain engagement in lessons that might otherwise be perceived as repetitive [19], [27], echoing meta-analyses that highlight motivation as a key mediator of technology-enhanced learning outcomes [23], [28].

Several limitations should be acknowledged. The lack of a control group is a significant limitation of this exploratory study, as internal validity threats such as maturation or testing effects cannot be entirely ruled out. Consequently, the 21-percentage-point gain should be interpreted as a preliminary indicator of pedagogical potential rather than a definitive measure of AR's efficacy. The use of convenience sampling in a single school context limits the generalizability of the findings to broader populations. Consequently, the results should be interpreted primarily as exploratory evidence derived from a specific classroom context rather than as broadly generalizable conclusions. Potential novelty effects—where students' enthusiasm for the technology itself drives engagement [26]—must also be considered. Another limitation concerns the assessment instrument. The grammar test was a researcher-developed classroom measure and was not formally validated. Although it was aligned with the curricular content of the instructional unit, future studies should employ or develop validated instruments capable of capturing more fine-grained differences in grammatical performance. Future research should incorporate longer interventions, larger samples, and more robust outcome measures, while comparing different delivery modes (e.g., tablets vs. headsets) to determine their relative pedagogical value [11], [29]. Implementation studies that examine teacher training, classroom orchestration, and cost–benefit trade-offs would also be valuable.

Despite these caveats, this classroom-based intervention contributes to the growing body of evidence on the role of immersive technologies in language education. In line with other recent studies [20], [22], [30], the results suggest that AR can enrich grammar instruction by making abstract forms more visible, memorable, and contextually grounded. For teachers, AR offers a practical and engaging medium to support explicit grammar instruction, particularly when resources are limited but tablets are available. For researchers, the findings highlight the need for scaled-up, longitudinal studies to examine sustainability, transfer of learning, and broader curricular integration.

In broader terms, this study illustrates how technological innovation, when paired with sound pedagogy, can make grammar learning more interactive and inclusive for adolescent learners. Lightweight AR has the potential not only to complement traditional instruction but also to open new pathways for collaboration, motivation, and experiential learning in secondary EFL classrooms.

5 CONCLUSION

This exploratory study suggests that mobile augmented reality delivered on tablets may complement conventional instruction for teaching English conditionals in secondary education. Gains were strongest for first and second conditionals, with modest improvements for third conditional recognition. The results support further, longer-term research and scaled classroom implementations of interactive mobile technologies. In this sense, the present study may serve as a preliminary reference for researchers and educators interested in designing and evaluating AR-supported grammar learning activities in comparable educational contexts. Future studies conducted in diverse educational contexts will be necessary to examine the broader applicability and transferability of AR-supported grammar learning approaches.

5.1 Acknowledgments

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5.2 Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

5.3 Author contributions

MM-B: investigation, implementation of the classroom intervention, data collection, and writing original draft preparation. JB-M: conceptualization, supervision, funding acquisition, writing –review, and editing.

5.4 Both authors

Data analysis, interpretation of the results

5.5 Funding

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5.6 Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

5.7 Ethics statement

The classroom intervention reported in this study formed part of the broader research project EDUC-AR (CIAICO-2022-079), a three-year research initiative investigating the pedagogical impact of augmented reality in English language teaching and learning. The project received ethical approval from the Ethics Committee of the University of Alicante (approval code: UA-2024-07-25). Participation was voluntary; informed consent was obtained from students and/or their legal guardians in accordance with school regulations, and all collected data were anonymized prior to analysis.

6 GENERATIVE AI STATEMENT

The authors declare that no generative AI tools were used in the writing or analysis of this manuscript.

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