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Original Research

Virtual reality and learner autonomy in EFL classes: A quasi-experimental study

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Evidence remains limited on how self-reported learner autonomy changes when EFL students practise the same language material through immersive VR and desktop activities. This quasi-experimental study compared changes in two existing classes of Omani foundation-programme students during six weeks of vocabulary instruction. Forty pre-intermediate learners participated, with 20 students in each class. One class used immersive VR, while the other completed desktop activities based on the same 20 words and expressions, weekly schedule, spoken-response format, and teacher. Participants completed the 23-item Language Learner Autonomy Scale before and after instruction. A 2 × 2 mixed ANOVA examined the Time × Group interaction for the total score, followed by secondary analyses of the six subscales. The mean total score increased from 71.45 to 90.40 in the VR class and from 69.65 to 73.05 in the desktop class, producing a 15.55-point difference between their mean gains. The Time × Group interaction was statistically significant, $F(1, 38) = 208.95$, $p < .001$, partial $\eta^2 = .846$, and the VR class reported larger gains on all six subscales. The subscale pattern connected immersive vocabulary practice with students' reported motivation, persistence, and management of learning. The study contributes a pretest–posttest active comparison from an underrepresented Omani foundation-programme context and relates immersive task design to students' perceived responsibility during structured digital practice under closely matched instructional conditions.

Keywords: *learner autonomy, immersive virtual reality, English as a foreign language, vocabulary learning, self-regulated learning, quasi-experimental design, Oman*

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1. INTRODUCTION

Language learning continues outside scheduled lessons through review, practice, and the use of resources, which makes students' management of their own study central to sustained progress. Learner autonomy is commonly associated with students' capacity to assume responsibility for decisions concerning their learning, including what they need to learn, how they will proceed, and how they will assess their progress (Benson, 2010, 2013; Holec, 1981; Little, 1991). In classroom settings, such

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responsibility can develop with teacher support and peer interaction, since autonomy does not require students to study in isolation or without instruction (Littlewood, 1999; Palfreyman, 2011). EFL learners may nevertheless have limited experience of directing their studies, while curricular demands and established classroom practices can restrict the decisions available to them (Cirocki et al., 2019; Fauzi et al., 2020; Jiménez Raya & Vieira, 2020).

Digital instruction can change how practice, feedback, and student responsibility are arranged. Flipped instruction has been associated with higher learner-autonomy scores and increased opportunities for self-directed study (Behforouz & Al Ghaithi, 2025; Zainuddin & Perera, 2019), while text messaging and videoconferencing have been used to support independent language practice outside regular lessons (Behforouz & Frumuselu, 2020; Lenkaitis, 2020). Digital resources may allow students to repeat activities, work at their own pace, and receive feedback without waiting for direct teacher intervention (Kul, 2023; Reinders & White, 2016). The presence of technology alone says little about the responsibility students assume, however, since this depends on the decisions permitted by the activity and the type of support provided.

Immersive VR places language activities in simulated environments where students can interact with objects and respond to situated prompts (Loup et al., 2016; Parmaxi et al., 2017). Research in language education has associated VR and three-dimensional virtual environments with vocabulary learning, retention, motivation, and affective outcomes (Huang et al., 2021; Wang et al., 2020). Tseng et al. (2020), for example, reported improved long-term vocabulary retention under paired autonomous practice, although autonomy described the practice arrangement and was not assessed as an outcome. Hsu (2024) studied learners' perceptions of self-paced immersive VR, including its usefulness and usability, while Alharbi (2022) considered opportunities for autonomous learning in virtual classes. These studies connect immersive environments with independent practice and positive learner responses, yet they provide limited evidence about whether students report changes in their capacity to manage their learning.

Learner autonomy and students' reports of their autonomy are distinct outcomes. Questionnaire scores can indicate how learners assess their motivation, effort, persistence, planning, and management of study at a given time, while direct evidence of autonomous behaviour requires observation or other behavioural records. Learner-autonomy research relies extensively on questionnaires, many of which were developed years ago for use in formal educational settings (Liu et al., 2026). Research specifically assessing changes in self-reported learner autonomy during immersive VR instruction remains limited (Fernández-Arias et al., 2026), as does evidence from comparisons in which VR and desktop classes study the same language material. Since institutional expectations, teacher support, and educational culture can affect learner responsibility (Alharbi, 2022; Jiménez Raya & Vieira, 2020), findings from one educational setting cannot be assumed to apply unchanged to another.

The present study aimed to compare changes in self-reported learner autonomy during six weeks of immersive VR and desktop vocabulary activities in two Omani foundation-programme EFL classes. Both classes studied the same target vocabulary with the same teacher and completed the learner autonomy questionnaire before and after instruction. The study addressed the following research question: How did self-reported learner autonomy change over six weeks in each class, and how did the changes compare?

2. THEORETICAL BACKGROUND

2.1. Learner autonomy in EFL

Since Holec (1981) defined learner autonomy as the capacity to assume responsibility for one's learning, later accounts have developed the idea through students' control over learning decisions, reflective involvement, and willingness to act independently (Akopova, 2024; Benson, 2010, 2013; Little, 1991). Such responsibility may include identifying needs, setting goals, selecting appropriate resources, planning study, monitoring progress, and evaluating outcomes (Candy, 1991; Grishechko, 2024). Autonomy can therefore vary according to the learner, the task, and the educational setting. A student may take responsibility for some decisions while continuing to depend on the teacher for others.

Autonomy is compatible with instruction, collaboration, and assistance from other people (Adediwura, 2012; Benson & Voller, 1997). Littlewood (1999) connects it with a gradual increase in students' ability and willingness to make learning decisions, while Palfreyman (2011) places autonomous learning in a social setting where peers, teachers, and institutions influence the opportunities available to students.

A learner who requests feedback or works with classmates may still exercise autonomy, provided that the learner assumes some responsibility for the learning process. Teachers can support this responsibility when they explain available choices, encourage reflection, and allow students to monitor their own progress (Reinders & White, 2016; Snodin, 2013; Yuan & Kim, 2018).

Self-regulation is closely related to learner autonomy, although the two terms refer to different aspects of learning. Self-regulation concerns the processes through which students plan, monitor, and evaluate their work, whereas learner autonomy also concerns their willingness and authority to assume responsibility for learning decisions. Cao and Pho (2024) combine these aspects in an account based

Volume 10 Issue 3, 2026, pp. 142-154 doi: 10.22363/2521-442X-2026-10-3-142-154

on two main areas, self-initiation and self-regulation. Self-initiation includes motivation and attitudes, openness to new things, making efforts to learn, and perseverance. Self-regulation includes identifying needs and learning goals and planning and monitoring the learning process. Motivation contributes to a learner's willingness to accept responsibility, while planning and monitoring concern the management of that responsibility over time.

The expression of autonomy also depends on the opportunities provided by a course and its institutional setting. Curricular requirements, assessment practices, limited preparation, and established expectations about teacher authority may restrict the decisions students can make (Jiménez Raya & Vieira, 2020; Marzuki et al., 2023). Research with EFL learners has consequently reported differing levels of readiness to direct learning (Cirocki et al., 2019; Fauzi et al., 2020). In an Omani university preparatory programme, Vellanki et al. (2024) found that explicit metacognitive strategy instruction was associated with improvement in listening performance and reported awareness of planning, directed attention, and evaluation. Their participants were advanced learners studying listening, so the findings do not establish how pre-intermediate students respond to vocabulary instruction, though they show that self-management in Omani EFL education can change in response to a planned instructional experience (Vellanki et al., 2024).

2.2. Self-report assessment of learner autonomy

Learner autonomy includes capacities and decisions that are difficult to assess from a single external perspective. Classroom observation can document behaviour, such as seeking resources or monitoring task completion, but it cannot fully establish how students understand their responsibility for learning. Interviews, learning diaries, questionnaires, performance records, and observation consequently provide different kinds of evidence. A recent review of 61 studies found that 56 used questionnaires, while observational records such as field notes were rare (Chong & Reinders, 2025). Much of the empirical literature therefore concerns perceived autonomy (Chong & Reinders, 2025).

Questionnaire responses indicate how students assess their own motivation, effort, perseverance, planning, and monitoring at the time of administration. Changes between a pretest and posttest can show that these assessments changed during an instructional period. They cannot confirm corresponding changes in independent behaviour, nor can they determine whether any change continued after the course. Responses may also be affected by students' understanding of the items, their expectations about desirable answers, and their immediate reaction to an unfamiliar instructional activity. Claims based on such scores must therefore refer to self-reported learner autonomy.

The Language Learner Autonomy Scale (LLAS) developed by Cao and Pho (2024) provides a concise measure of self-initiation and self-regulation. Its 23 items are distributed among six subscales: motivation and attitudes, openness to new things, making efforts to learn, perseverance, identifying needs and learning goals, and planning and monitoring the learning process. This structure joins students' willingness to assume responsibility with their reported management of learning. The total score consequently represents a composite self-assessment. A rise in the total may result from change in one or several subscales, so subscale findings are needed when the discussion concerns a particular aspect of autonomy.

The scale was developed with Vietnamese university students majoring in English, which makes its use with Omani foundation students an application in a new linguistic and educational setting. Translation review can assess the clarity and equivalence of the wording, while local piloting can provide an initial estimate of internal consistency in that setting. These procedures do not convert the questionnaire into a behavioural measure, but support its use as an assessment of how participants report their learner autonomy.

2.3. Digital language instruction and learner autonomy

Digital language instruction can alter the distribution of practice and feedback between teachers, students, and software. Students may repeat an activity without waiting for the teacher, receive an immediate response, and continue at an individual pace. Access to digital resources can also support study outside scheduled lessons (Chik, 2014; Lai et al., 2016; Reinders & White, 2016). These opportunities may contribute to self-initiation and self-regulation when students use them to sustain effort, respond to feedback, or monitor progress (Malakhova, 2026; Osiyanova et al., 2024).

Evidence from particular technologies suggests that such effects depend on the instructional activity. Flipped instruction has been associated with higher autonomy scores and greater participation in self-directed study (Behforouz & Al Ghaithi, 2025; Zainuddin & Perera, 2019), while text messaging has been used to support learning outside regular classroom contact (Behforouz & Frumuselu, 2020). Lenkaitis (2020) describes videoconferencing as a setting in which learners can assume responsibility for language practice through interaction with others. These technologies differ considerably in the choices they permit, the support they provide, and the responsibility retained by the teacher.

A prescribed digital task may support persistence and independent repetition even when students cannot choose the target material. It provides less direct opportunity to set goals, select resources, or plan the sequence of study.

The presence of immediate software feedback may reduce dependence on an immediate teacher response, yet it does not itself transfer control over the curriculum to the student. Any connection between a digital activity and learner autonomy must therefore be stated in relation to the decisions and forms of self-management that the activity actually permits (Richards & Rodgers, 2014).

In vocabulary practice based on a fixed word list, self-management occurs under clear instructional limits. Students may regulate their attention, continue after an error, repeat a spoken response, and monitor their progress, though the vocabulary and task order remain prescribed. An autonomy questionnaire may register changes in how students assess their motivation or management of study. Such scores provide limited evidence about students' authority over learning aims or content.

2.4. VR and desktop language activities

Immersive VR presents a simulated environment through a head-mounted display and allows the user to respond to objects or prompts through movement, speech, or handheld controls (Lan, 2020). Desktop activities present digital material on a conventional screen and rely on familiar input devices. Both formats can provide practice and automated feedback, but the sensory experience and mode of interaction differ (Petersen et al., 2022). The educational effect of that difference depends on the task, the duration of exposure, the quality of feedback, and students' familiarity with the equipment.

Reviews of immersive VR research report generally positive learner perceptions, alongside less consistent evidence about learning. Dhimolea et al. (2022) reviewed 32 studies of high-immersion VR in language learning and found support for contextualised vocabulary practice and repeated exposure, while conclusions about effectiveness remained uncertain. A meta-analysis covering 48 immersive VR studies in education estimated a small average effect on learning outcomes and found variation according to educational level and the comparison activity (Coban et al., 2022). These findings give no basis for assuming that immersion produces the same outcome under every instructional design (Coban et al., 2022; Dhimolea et al., 2022; Makransky et al., 2019).

Language-learning studies have concentrated mainly on vocabulary acquisition, speaking, motivation, anxiety, engagement, and satisfaction (Huang et al., 2021; Wang et al., 2020). Tseng et al. (2020) found higher long-term vocabulary retention under paired autonomous practice in a three-dimensional virtual environment. In that study, 'autonomous' described how the practice was organised, and learner autonomy was not assessed as a changing outcome. Hsu (2024) examined students' perceptions of self-paced immersive VR, including usefulness and usability, while Raman et al. (2023) reported favourable ratings of engagement, motivation, and autonomous learning after VR-supported lessons. Since Raman et al. collected these ratings after the activity, the study provides evidence about participants' responses to VR but does not establish pretest-to-posttest change.

Research that measures learner autonomy directly has produced less uniform findings. Wu and Hung (2022) compared VR- and picture-supported instruction among 56 elementary EFL learners. The VR group improved in grammar and lexical use, but the groups did not differ significantly in learning autonomy, willingness to communicate, pronunciation, fluency, or intonation. Their findings also separate language achievement from autonomy, since improvement in one outcome did not entail improvement in the other. Differences in learner age, activity type, duration, and comparison condition limit direct application to adult foundation students, but the study shows that positive language outcomes cannot be used as evidence of greater learner autonomy (Wu & Hung, 2022).

A desktop class provides an active digital comparison for immersive VR. Students in both formats can receive technology-supported vocabulary practice, while the interface and activity experience differ. When the target vocabulary, teacher, and instructional period are kept similar, the comparison offers evidence about changes observed during the two forms of instruction. It does not isolate immersion from every other difference between their complete classroom experiences. The appropriate outcome is therefore the difference in self-reported learner autonomy under the two activity formats, with claims confined to the classes and measures used.

3. METHODOLOGY

3.1. Design and ethical considerations

The study used a two-group pretest—posttest quasi-experimental design with two existing classes. One class completed immersive VR vocabulary activities, while the other completed desktop vocabulary activities. Learner autonomy questionnaire scores were collected before and after six weeks of instruction. The University Ethics and Biosafety Committee (UEBC) at Sohar University approved the study in 2026 under reference number UEB 2027—SU Staff—05. Participation was voluntary. During the consent process, students were informed that they could decline without consequences for their course grades. All participants provided informed consent before data collection. The data were used only for the stated research purposes.

3.2. Participants and setting

The participants were 40 students taking preparatory courses in the Foundation Department of a higher education institution in Oman. The department provides approximately one to two years of introductory instruction

Volume 10 Issue 3, 2026, pp. 142-154 doi: 10.22363/2521-442X-2026-10-3-142-154

in information technology, mathematics, and English, based on the Omani national curriculum, to prepare students for their degree specialisations. The institution's placement test classified the students' English proficiency as pre-intermediate. All participants were Omani nationals aged 18 to 20, and their first language was Omani Arabic. The study involved two existing classes of 20 students. One class used immersive VR and the other used desktop computers. The same researcher taught both classes. All 40 students provided complete pretest and posttest questionnaire data and were included in the analysis.

3.3. Instructional materials

3.3.1. Immersive VR activities

A game developer created a custom English-learning platform from a script written by the researcher. The platform used speech recognition, real-time rendering, visual scripting, and event-based programming to support object interaction, spoken responses, feedback, and progression through the activities. Students located objects or completed actions in a virtual home and practised the associated English words or expressions aloud. The platform ran on Meta Quest 3 headsets and used the offline Speech To Life plugin (Solar Storm Interactive, 2026).

Spoken responses were converted to text and compared with the expected words. The programme checked whether the intended word was recognised and did not assess pronunciation accuracy. A recognised answer allowed the student to continue. An unrecognised answer prompted another attempt. After three unsuccessful attempts, the programme supplied pronunciation assistance and further practice.

The Meta Quest 3 provided stereoscopic visual presentation and sound, while two Touch Plus controllers allowed movement and object interaction.

In one activity, for example, participating students were asked to locate a table lamp, point to it, and say its name. Directional arrows helped them locate an object when assistance was needed. Figure 1 shows views of the activity.

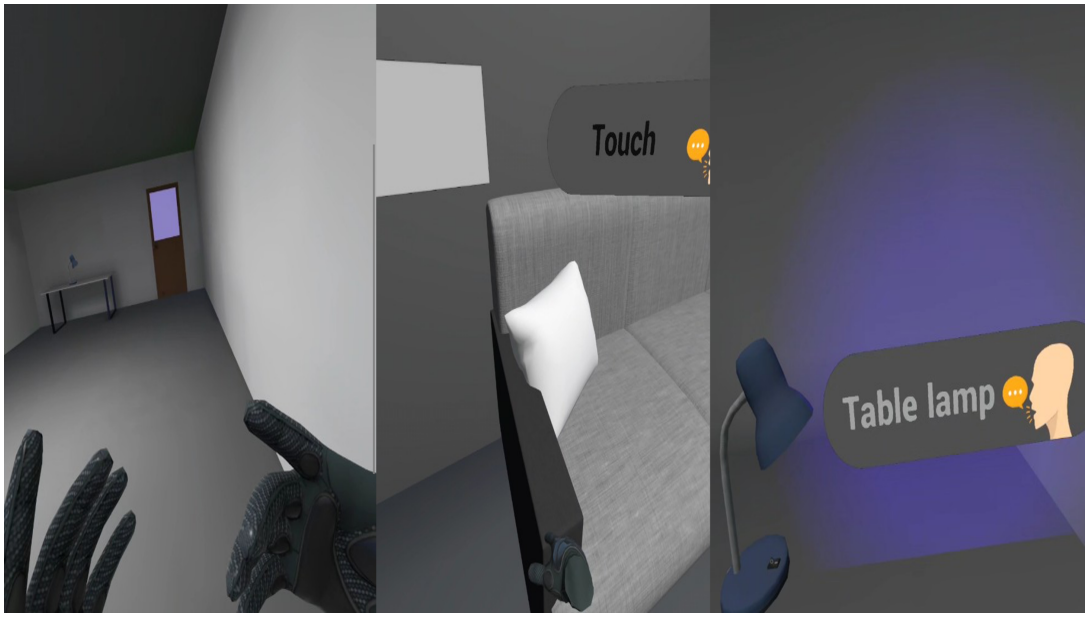

Figure 1. Views of the VR activity
(left: virtual room and hand controls; centre: the 'touch' prompt beside an object; right: the 'table lamp' label)

3.3.2. Desktop activities

The desktop class used existing non-immersive, web-based interactive materials. Students worked individually on desktop computers, followed instructions, and completed spoken vocabulary activities using digital representations of the same objects and actions presented to the VR class. An accepted spoken answer allowed the student to continue, while an unsuccessful answer prompted another attempt. Pronunciation assistance was supplied after three unsuccessful attempts. The activities followed the same weekly topics, target vocabulary, session schedule, and progression rule as the VR activities. Students could report access or technical problems to the researcher, who supervised the activities.

3.3.3. Comparison of the instructional activities

Both classes studied the same 20 target words and expressions with the same teacher over the same six-week

period. The classes differed in equipment, visual presentation, physical interaction, grouping, and prior familiarity with the instructional format. Table 1 gives the recorded features of the two activities.

3.4. Learner autonomy questionnaire

Self-reported learner autonomy was assessed with the Language Learner Autonomy Scale (LLAS) developed by Cao and Pho (2024). The scale measures students' reported capacity to initiate and regulate their learning. Its initial version contained 26 items adapted from three existing learner-autonomy questionnaires and was tested with 220 first- and second-year English students in Vietnam. Three items were removed because of weak item correlations and the results of the factor analysis.

The final questionnaire used in the present study contains 23 items divided between self-initiation and self-regulation.

Self-initiation comprises four subscales. Motivation and attitudes contains three items concerning willingness to learn, attitudes towards English, and motivation without external encouragement. Openness to new things contains three items concerning new methods, experiences, and challenges. Making efforts to learn contains three items concerning teamwork, requests for peer assistance, and participation in classroom activities. Perseverance contains three items concerning difficult tasks, deadlines, and responsibility for learning.

Self-regulation comprises two subscales. Identifying needs and learning goals contains five items concerning goal setting, recognition of learning needs and problems, awareness of strengths and weaknesses, and evaluation of goal achievement. Planning and monitoring the learning process contains six items concerning the selection of materials, independent information seeking, learning strategies, individual study, selection of suitable study locations, and daily or weekly planning.

Participants rated each statement on a five-point Likert scale, where 1 represented *Strongly Disagree*, 2 *Disagree*, 3 *Neutral*, 4 *Agree*, and 5 *Strongly Agree*. Item scores were summed. The possible total score ranged from 23 to 115, with higher scores indicating higher self-reported

Table 1
Comparison of the instructional activities

FEATURE	VR CLASS	DESKTOP CLASS
Delivery format	Immersive virtual environment	Non-immersive web-based activities
Equipment	Meta Quest 3 headset and Touch Plus controllers	Desktop computer
Grouping	Five subgroups of four	Individual computer work
Target vocabulary	Same 20 words and expressions	Same 20 words and expressions
Weekly topics	House exterior and entrance hall, living room, kitchen, bathroom, and bedroom	House exterior and entrance hall, living room, kitchen, bathroom, and bedroom
Schedule	Ten 20-minute sessions and one 30-minute review	Ten 20-minute sessions and one 30-minute review
Student response	Spoken response	Spoken response
Progression rule	Recognised answer permitted progress	Accepted answer permitted progress
Error support	Further attempts and pronunciation assistance after three unsuccessful attempts	Further attempts and pronunciation assistance after three unsuccessful attempts
Week 6 review	Interactive VR shooting activity	Computer-based shooting activity
Preliminary experience	A 60-minute headset orientation	Previous experience with the desktop materials
Teacher	Same researcher	Same researcher

Volume 10 Issue 3, 2026, pp. 142-154 doi: 10.22363/2521-442X-2026-10-3-142-154

learner autonomy. Each three-item subscale could range from 3 to 15, the five-item subscale from 5 to 25, and the six-item subscale from 6 to 30.

In the Vietnamese development study, Cronbach's alpha was .778 for motivation and attitudes, .759 for openness to new things, .714 for making efforts to learn, .705 for perseverance, .804 for identifying needs and learning goals, and .746 for planning and monitoring the learning process. The total alpha for the 23 items was .888. Principal components extraction with Varimax rotation produced six factors, with item loadings ranging from .528 to .855 (Cao & Pho, 2024). A separate Omani pilot involved 20 students whose English proficiency corresponded to that of the main-study participants. None of these students participated in the main study. Cronbach's alpha for the complete 23-item questionnaire was .855. The small pilot supplied a tentative estimate for the total scale and did not establish reliability separately for the six subscales. The six subscale analyses were therefore secondary.

A professional Arabic—English speaker prepared an Arabic translation, which appeared beside the English statements to support comprehension. Two Omani specialists with PhDs in Applied Linguistics reviewed the English and Arabic versions for clarity, relevance, semantic equivalence, and cultural and academic suitability. They identified no discrepancies requiring revision. No cognitive interviews or structured student-comprehension checks were conducted during the pilot.

3.5. Procedure

The intervention took place during the second semester of the 2025—2026 academic year. Students received information about the purpose, procedures, and ethical requirements of the study before signing the consent form. One week before instruction began, both classes completed the learner autonomy questionnaire. Before the first VR session, the VR class attended a 60-minute orientation to the Meta Quest 3. Students practised adjusting the headset, using the controllers, moving through the virtual environment, and interacting with objects. The orientation was intended to reduce equipment-related difficulties and was excluded from the planned instructional time. The desktop class received no preliminary training because its students had used the desktop materials during the previous semester. Five Meta Quest 3 headsets were available, and the 20 students in the VR class were divided into five subgroups of four. Each subgroup was scheduled for two 20-minute sessions per week during the first five weeks. The desktop class followed the same schedule. Weekly instruction covered the house exterior and entrance hall, living room, kitchen, bathroom, and bedroom, in that order.

The activities covered the following 20 target words and expressions: *walk up, ring, enter, pick up, table lamp, turn on, touch, straighten up, read, put down, open, put away, cook, turn off, brush, rinse off, lift, close up, take,* and *pack up.* In both classes, students followed instructions, identified objects or actions, and produced the associated words or expressions aloud. The activity sequence was fixed. Students could not choose the target words, change the task order, or skip activities.

During Week 6, the VR class completed a 30-minute interactive shooting activity that required retrieval of the previously studied words and expressions. The desktop class completed a corresponding 30-minute computer-based shooting activity based on the same vocabulary. The researcher supervised both review activities.

The planned instruction totalled 230 minutes per student, consisting of ten 20-minute sessions and one 30-minute review. The VR orientation added 60 minutes of equipment familiarisation. Attendance and technical interruptions were not systematically recorded, so the amount of practice completed by each student could not be confirmed.

Both classes completed the learner autonomy questionnaire again after the six-week intervention.

3.6. Statistical analysis

The analyses were conducted in SPSS 27. Means and standard deviations were calculated for the pretest and posttest scores. Gain scores were calculated as the posttest score minus the pretest score.

The principal analysis was the Time × Group interaction from a 2 × 2 mixed ANOVA of the total questionnaire score. Time consisted of the pretest and posttest measurements, and Group consisted of the VR and desktop classes. The interaction tested whether the amount of change differed between the two classes. Statistical significance for the principal analysis was assessed at $\alpha = .05$, and partial n^2 was reported as the effect-size estimate.

Shapiro—Wilk tests were available for the total scores at each measurement occasion. Given the sample of 20 students per class, nonsignificant results were interpreted cautiously and were not taken as proof of normality.

A multivariate analysis using Pillai's trace examined the six subscales together. Separate Time × Group interaction tests were then conducted for the six subscales. These analyses were secondary because reliability had not been established separately for the subscales in the Omani sample. A Bonferroni-adjusted threshold of .05/6 = .0083 was applied to the six interaction tests, and partial n^2 was reported for each effect.

All inferential calculations used individual student records without adjustment for class membership. Since one class received each activity, variation between classes could not be estimated separately from the difference between the instructional activities. Therefore, the resulting p-values were provisional and could not establish that VR caused any difference in questionnaire-score gains.

4. RESULTS

The Shapiro—Wilk tests did not detect departures from normality in the four total-score distributions. The W values ranged from .945 to .982, and the p values ranged from .297 to .953. Table 2 presents the pretest and posttest descriptive statistics for the desktop and VR classes.

The mean total LLAS score increased from 69.65 (*SD* = 10.17) to 73.05 (*SD* = 10.38) in the desktop class and from 71.45 (*SD* = 10.77) to 90.40 (*SD* = 10.25) in the VR class. The mean total gain was 3.40 points (*SD* = 2.93) in the desktop class and 18.95 points (*SD* = 3.82) in the VR class. For the six subscales, mean gains ranged from 0.10 to 1.10 points in the desktop class and from 2.40 to 4.60 points in the VR class. The primary mixed ANOVA found a statistically significant Time × Group interaction for the total LLAS score, $F(1, 38) = 208.95$, $p < .001$, partial $n^2 = .846$. The difference between the mean gains of the two classes was 15.55 points. The full mixed ANOVA results are reported in Table 3.

The multivariate analysis also found a statistically significant Time × Group interaction for the six LLAS subscales considered together, Pillai's trace = .869, $F(6, 33) = 36.397$, $p < .001$, partial $n^2 = .869$. The multivariate results are presented in Table 4.

The secondary analyses tested separate Time × Group interactions for the six subscales. As reported in Table 5, all six tests had $p < .001$ and met the Bonferroni-adjusted significance threshold of .0083. Partial n^2 values ranged from .309 for making efforts to learn to .523 for openness to new things. The descriptive statistics in Table 2 show a larger mean gain in the VR class for each subscale.

Table 2
Descriptive statistics for the desktop and VR classes at pretest and posttest

LLAS MEASURE	DESKTOP CLASS PRE M (SD)	DESKTOP CLASS POST M (SD)	VR CLASS PRE M (SD)	VR CLASS POST M (SD)
Motivation and attitudes	9.30 (1.92)	9.40 (1.88)	9.35 (1.81)	11.90 (1.59)
Openness to new things	8.95 (1.93)	9.75 (2.07)	8.80 (1.79)	11.75 (2.05)
Making efforts to learn	9.45 (1.54)	9.85 (1.90)	9.25 (1.89)	11.65 (1.79)
Perseverance	9.20 (1.61)	9.75 (2.17)	9.45 (1.67)	12.15 (1.73)
Identifying needs and learning goals	15.00 (2.79)	15.45 (2.72)	15.75 (2.88)	19.50 (2.72)
Planning and monitoring the learning process	17.75 (3.43)	18.85 (3.05)	18.85 (3.03)	23.45 (3.32)
Total LLAS score	69.65 (10.17)	73.05 (10.38)	71.45 (10.77)	90.40 (10.25)

Note. n = 20 per class. M = mean. SD = standard deviation.

Table 3
Mixed ANOVA for the total LLAS score

EFFECT	df1	df2	F	p	PARTIAL η^2
Time	1	38	431.66	< .001	.919
Group	1	38	8.72	.005	.187
Time × Group	1	38	208.95	< .001	.846

Note. Time refers to the change from pretest to posttest. The Time × Group interaction tests whether the two classes changed differently over the six-week period.

Volume 10 Issue 3, 2026, pp. 142-154 doi: 10.22363/2521-442X-2026-10-3-142-154

Table 4
Multivariate analysis of the six LLAS subscales

EFFECT	PILLAI'S TRACE	F	HYPOTHESIS df	ERROR df	p	PARTIAL η^2
Time	.934	77.747	6	33	< .001	.934
Group	.314	2.518	6	33	.041	.314
Time × Group	.869	36.397	6	33	< .001	.869

Note. The analysis includes motivation and attitudes, openness to new things, making efforts to learn, perseverance, identifying needs and learning goals, and planning and monitoring the learning process.

Table 5
Time × Group Interactions for the LLAS subscales

SUBSCALE	df1	df2	F	p	PARTIAL η^2
Motivation and attitudes	1	38	38.825	< .001	.505
Openness to new things	1	38	41.674	< .001	.523
Making efforts to learn	1	38	16.964	< .001	.309
Perseverance	1	38	20.155	< .001	.347
Identifying needs and learning goals	1	38	41.094	< .001	.520
Planning and monitoring the learning process	1	38	21.102	< .001	.357

Note. The Bonferroni-adjusted significance threshold for the six subscale tests was .0083 (.05 ÷ 6).

5. DISCUSSION

5.1. Interpretation of principal findings

Over the six-week instructional period, the total LLAS score increased in both classes, although the mean gain in the VR class was 18.95 points, compared with 3.40 points in the desktop class, giving a difference in gains of 15.55 points. This difference was reflected in a statistically significant Time × Group interaction, $F(1, 38) = 208.95$, $p < .001$, partial $n^2 = .846$. The secondary analyses showed the same general pattern in all six LLAS subscales, for which the Time × Group interactions remained significant under the Bonferroni-adjusted threshold. The principal finding is therefore a difference in the extent of reported change during the two forms of vocabulary instruction, with a modest increase in the desktop class and a much larger increase in the VR class.

The subscale results help explain the nature of this difference because they include both areas represented in the LLAS. Four subscales concern self-initiation: motivation and attitudes, openness to new things, making efforts to learn, and perseverance. The other two concern self-regulation through the identification of needs and learning goals and the planning and monitoring of learning. The larger gains in the VR class therefore included students' reported willingness to engage with learning as well as their assessment of how they organise and monitor it. Since the total LLAS score combines these six subscales, the difference in total gains reflects a general change in how the VR students assessed their capacity to initiate and regulate learning, instead of an increase confined to one particular aspect of the questionnaire.

The meaning of this reported change becomes clearer when considered in relation to the activities themselves. Both classes practised the same vocabulary, followed the same weekly sequence, produced spoken responses, repeated unsuccessful answers, and received software assistance before continuing. These requirements placed some responsibility on students to maintain attention, persist after errors, and respond to feedback during individual practice. The VR class completed this work through a stereoscopic environment in which students moved through a simulated home, located objects, interacted with them, and

produced the corresponding words or expressions. The combination of movement, contextual presentation, spoken response, and immediate continuation may have made progress through the activity more perceptible to students, which could support a stronger sense of persistence and control over task completion.

The desktop class also showed a smaller positive gain. Its students completed structured digital practice with repeated spoken responses and feedback, and their total LLAS score rose by 3.40 points. The VR class therefore differed in the size of the reported change, while the results from both classes remain compatible with an association between structured digital practice and students' assessment of their autonomy. The additional features of the VR activity, including physical interaction with objects and movement through a simulated setting, provide a plausible account of the larger change recorded in that class.

At the same time, the form of autonomy involved in these activities was bounded by their instructional design. The teacher and software determined the vocabulary, sequence, expected responses, and progression through the tasks, while students managed their attention, effort, persistence, and use of feedback during completion. These forms of self-management correspond directly to several LLAS subscales, especially making efforts to learn, perseverance, and planning and monitoring the learning process. The subscales concerning needs, goals, and the selection of learning resources refer to decisions of a different kind because those decisions were prescribed during the intervention. The increase in these scores may therefore reflect a more general change in students' confidence in managing learning after successful participation in the activities. The questionnaire assessed their view of their own capacities, and such self-assessments can encompass situations outside the specific decisions required during each lesson.

5.2. Relation to previous research

The direction of the findings is consistent with earlier research in which learners gave favourable accounts of autonomy during or after work in virtual environments. Raman et al. (2023) reported positive ratings of autonomous learning, engagement, and motivation following VR-supported communication activities, while Tanashur et al. (2025) found an association between VR use and learner autonomy, together with self-paced learning and reflection. Yeh and Lan (2018) likewise reported greater autonomy, motivation, goal setting, and participation among students who created virtual environments for subsequent English lessons.

Although the technologies and activities differed, these studies and the present results associate participation in virtual environments with positive assessments of students' involvement in managing learning.

The study adds a temporal comparison to this body of evidence because the LLAS was administered before and after instruction in both a VR class and an active desktop class. The scores in both classes changed in the same positive direction, although the amount of change differed, a pattern that cannot be seen in studies relying solely on responses collected after an activity. The use of the same teacher, vocabulary, schedule, and spoken-response format also places the difference in a more closely specified instructional comparison.

Other research shows that higher autonomy scores do not follow every use of VR in language education. Wu and Hung (2022) found improvements in grammar and lexical use among elementary EFL learners, while the VR-supported and picture-supported groups showed no significant difference in learning autonomy. Thus, language achievement and reported autonomy can respond differently to the same instructional experience, which supports the distinction made in the present study between LLAS scores and language outcomes. Tseng et al. (2020) found greater long-term vocabulary retention under an autonomous practice arrangement in a 3D virtual environment, although their study assessed vocabulary retention under a particular organisation of practice. The present study addresses a different question because autonomy itself was measured before and after instruction. These findings place the instructional task, learner group, comparison activity, and selected outcome at the centre of any account of how virtual environments relate to autonomy.

5.3. Omani context and instructional implications

Research concerning learner autonomy in Omani EFL education has mainly addressed other proficiency levels, language skills, and forms of instruction. Vellanki et al. (2024), for example, reported improvement in listening performance and metacognitive awareness among advanced learners following explicit strategy instruction, including reported awareness of planning, attention, and evaluation. The present study concerns pre-intermediate foundation students, vocabulary practice, and a comparison between two forms of digital instruction. Its contribution is a pretest—posttest account of self-reported autonomy in an Omani population that has received limited attention in immersive VR research, supported by an active desktop comparison in which the language content, teacher, and instructional period were held constant.

The findings also have implications for the design of digital vocabulary activities. Repeated spoken practice, immediate assistance, and visible progress through a task can give students regular opportunities to regulate effort and persist after errors. Immersive presentation can place this practice in a coherent setting where words are connected with objects and actions, which may make task completion more immediate and personally involving. If the

instructional purpose includes a wider range of autonomous decisions, later activities could gradually allow students to select vocabulary, set personal targets, choose task order, request different forms of assistance, or evaluate their progress. Such additions would connect students' management of task completion with greater responsibility for the direction of learning.

5.4. Limitations

The findings come from two existing classes, with one class using each activity, so the difference between the instructional formats cannot be separated fully from other differences between the classes. Their similar proficiency and initial LLAS scores provide a useful starting comparison, although they do not establish identical patterns of later progress. Grouping, preparation, and previous familiarity with the materials also differed, and attendance, completed practice time, technical interruptions, and assistance received were not systematically recorded. The evidence concerns self-reported autonomy, while behavioural records of independent learning decisions were unavailable. The local reliability estimate came from a separate pilot of 20 students, reliability was not assessed for each subscale or main-study administration, and student comprehension of the Arabic translation was not tested through cognitive interviews. Responses may also have been affected by novelty, expectations, or socially desirable answering. The sample was drawn from one institution, and the study included no delayed posttest.

These considerations define the scope of the study's findings, which concern changes in LLAS scores among the two participating classes during the six-week intervention.

5.5. Directions for future research

Further studies could retain the matched vocabulary content and active digital comparison while including several classes for each activity or assigning students individually where feasible. Records of attendance, completed practice time, technical interruptions, prior VR experience, and assistance received would provide a fuller account of students' exposure to the activities. Additional testing of the Arabic LLAS with a larger Omani sample could establish reliability for the total scale and its six subscales, while learning logs, activity records, interviews, and classroom observation could relate questionnaire responses to students' decisions during and outside lessons. A delayed posttest could determine whether reported changes continue after the instructional period. Research informed by CAMIL (Makransky & Petersen, 2021) would require direct measures of presence, agency, self-efficacy, and cognitive load alongside learner-autonomy measures.

6. CONCLUSION

This study compared changes in self-reported learner autonomy among 40 pre-intermediate Omani foundation-programme EFL students who completed six weeks of vocabulary practice in two existing classes. One class used immersive VR, while the other completed desktop activities based on the same target vocabulary, schedule, and teacher. Students completed the 23-item LLAS before and after instruction. Scores increased in both classes, with the VR class reporting a considerably larger increase in the total score and in all six subscales associated with self-initiation and self-regulation.

The findings place immersive VR in an account of learner autonomy that connects digital task design with students' perceptions of their capacity to manage learning. Repeated spoken action, immediate feedback, continued practice after errors, and visible progress may support a stronger sense of effort, persistence, and self-management, even when the teacher and software determine the language content and sequence. Greater responsibility for goals, resources, and progression requires activities that permit students to make those decisions.

The evidence concerns perceived autonomy in two intact classes and supports a conclusion specific to this educational setting and questionnaire. The study contributes a pretest—posttest comparison from an Omani EFL population that has received limited attention in immersive VR research, while distinguishing reported autonomy from language achievement and observed independent behaviour.

Further research can build on this distinction through VR activities that permit genuine learner choice and through the joint assessment of questionnaire responses, learning decisions, and language outcomes.

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