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Enhancing 6th graders' listening skill through ARTutor4

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The paper explores the potential impact of implementing AR technology for enhancing 6th graders' listening skills in TEFL in the Greek primary education context. Its aim is to provide a detailed description of the present study and set the theoretical and pedagogical framework. A comprehensive literature review contextualizes the research within existing studies on AR in education. The methodological approach, including the sample and research tools, is described in detail. Moreover, key findings are presented and discussed, highlighting the potential of AR technology to enhance young EFL learners' listening proficiency. Finally, limitations of the study are acknowledged, and recommendations for future research are proposed to expand upon the use of AR in foreign language education.

Key words: AR, listening skills, TEFL, primary education

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1. Introduction

Nowadays the realm of the Augmented Reality (AR) technology has invaded in various sectors of human endeavours. During the last three decades AR has been used by large companies for visualisation and training purposes. Specifically, AR has been used in advertising, marketing, architecture, as well as in medicine, military, entertainment, and tourism. Moreover, the rising power of mobile devices enables the AR technology to be implemented in schools and universities. Nevertheless, there exists a dearth of comprehensive research exploring the educational benefits of AR technology within the field of Teaching English as a Foreign Language (TEFL) in tertiary, secondary, and especially primary education in Greece.

2. Literature review

The integration of AR technology into various domains has significantly transformed human activities, providing immersive and interactive experiences. However, in the context of education, particularly in TEFL, research remains limited. Tobar Muñoz *et al.* (2017) emphasise the underexplored affordances of AR within TEFL, especially when considering diverse educational levels. Arvanitis (2012) highlights this gap within Greece, where the implementation of AR in TEFL across tertiary, secondary,

and primary education has not been systematically examined. This issue is particularly pronounced in primary education, where the application of AR remains under-researched.

Moreover, a significant gap exists in the incorporation of AR to develop listening skills within TEFL. Parmaxi and Demetriou (2020) underline the lack of studies exploring this area, suggesting an urgent need for innovative approaches and empirical research. Listening is a foundational language skill, and the immersive capabilities of AR could provide learners with dynamic contexts for improving comprehension and engagement.

Finally, the development and evaluation of AR applications tailored for young learners aged five to twelve are limited. Barreira *et al.* (2012) highlight the lack of solutions designed to cater to this population, which represents a crucial stage for language acquisition. Such technologies could potentially foster language skills and enhance motivation among young learners.

The incorporation of AR technology into real-life classroom settings has the potential to significantly enhance learning outcomes when aligned with sound pedagogical principles. Lytridis and Tsinakos (2018) emphasise the necessity of such alignment to create optimal conditions for effective learning. This approach ensures that the integration of AR in education is not only innovative but also pedagogically effective, enhancing the overall teaching and learning experience. By grounding AR use in established theories of foreign language learning, educators can construct a coherent framework that bridges theoretical concepts with practical application. This theoretical perspective supports a meaningful and systematic integration of AR, ensuring that it enhances rather than disrupts traditional language learning processes.

Particularly, AR technology aligns closely with the learning-by-doing paradigm, which is rooted in constructivist, sociocultural, and situated learning theories (Dunleavy and Dede, 2014). AR facilitates hands-on, experiential learning by engaging learners in interactive and context-rich environments. This alignment not only fosters deeper engagement but also supports the active construction of knowledge in ways that reflect real-world experiences. Furthermore, the potential of AR is further amplified by its ability to create authentic and meaningful connections to the real world. Godwin-Jones (2016) argues that AR enhances contextual learning, a cornerstone of effective language learning practices. By simulating authentic scenarios and providing immediate feedback, AR technology allows learners to engage with foreign language in ways that mirror its use in real-life communication.

Finally, AR serves as a powerful tool for multimedia learning, creating immersive environments that activate schemata, provide scaffolding, and boost learners' motivation. According to Khoshnevisan and Le (2018) and Hadid *et al.* (2019), these immersive experiences foster active involvement and promote retention, making AR an effective medium for achieving educational goals.

Nevertheless, the incorporation of AR technology in primary education and the instruction of English as a Foreign Language engenders numerous challenges. A principal concern pertains to the cost and accessibility of AR. Schools operating with constrained financial resources may encounter difficulties in acquiring essential mobile devices, software applications, and requisite technical support (Bacca *et al.*, 2014). Furthermore, the digital divide has the potential to amplify educational inequalities, as learners from financially disadvantaged backgrounds may lack access to AR-compatible devices beyond the confines of the classroom (Dunleavy & Dede, 2014).

Another significant challenge is the lack of teacher training and readiness. Numerous educators do not possess the requisite digital literacy and pedagogical expertise needed to effectively incorporate AR into their instructional frameworks (Ibáñez & Delgado-Kloos, 2018). Without adequate

professional development, the application of AR tools may be limited or improperly incorporated, thereby diminishing their prospective advantages. Pedagogically, AR applications must align with educational objectives rather than serving as a superficial novelty. The development of AR experiences that facilitate profound learning, especially within the realm of TEFL, requires meticulous planning to ensure alignment with principles of foreign language acquisition, such as contextual learning and interactive communication (Godwin-Jones, 2016). Finally, concerns regarding student distraction and cognitive overload have been reported. Although AR technology can enhance students' motivation and engagement, the excessive use of visual and interactive elements may overwhelm younger learners, thereby hindering rather than facilitating the learning process (Cheng & Tsai, 2013).

To effectively address these challenges, it is important to implement economically viable AR solutions, focused teacher training, and pedagogically sound integration strategies to maximise the potential of AR tools in primary education and TEFL.

3. Study overview

This study aims to investigate the impact of AR technology on the enhancement of listening skills among 6th grade students within the context of TEFL in Greek public primary schools. Additionally, it seeks to evaluate the educational potential of the AR application ARTutor4, developed by the academic staff of the Advanced Educational Technologies and Mobile Applications (AETMA) Lab within the Computer Science Department at the Democritus University of Thrace in Greece (Terzopoulos *et al.*, 2022).

The primary research question driving this investigation is: Do the students in experimental groups, taught through AR-enhanced lessons, outperform their peers in control groups in overall listening performance in English? This question is addressed through the analysis of quantitative data collected from pre-tests, post-tests, and the results of three AR-enhanced lessons. Statistical tests are applied to process and interpret the data, ensuring valid evaluation.

The study was conducted from October 2023 to June 2024 at four state primary schools located in the municipality of Drama, Greece. Experimental and control groups were established to measure the differences in performance, providing a comparative framework for understanding the impact of the ARTutor4 application.

By combining cutting-edge AR technology with TEFL pedagogy, this research contributes to the growing body of evidence supporting innovative approaches in foreign language education. It highlights the potential of tools like ARTutor4 to transform traditional teaching methods, particularly in enhancing critical language skills such as listening.

4. Research methodology

To address the research question, the researcher conducts a quasi-experiment by working with intact classes of 6th graders, who were initially sorted in alphabetical order in these classes when they were 1st graders. Unlike true experiments that take place in controlled laboratories, the present quasi-experiment occurs in the natural setting of real primary school classrooms (Dörnyei, 2007). The classes of the students are randomly assigned as either experimental groups or control groups, and the members of these groups are randomly paired or grouped to work collaboratively. The experimental groups receive lessons enriched with augmentations, while the control groups are taught the same lessons devoid of AR elements. Pairing participants allows for the application of Constructivism, Sociocultural theory, and Situated Learning theory, supported by Dünser and Hornecker's (2007) findings on the benefits of cooperative AR book use.

Furthermore, the quasi-experimental research involves the deliberate manipulation of the conditions that influence the events, introduces an intervention, and causes possible outcomes that are measured in order for the research question to be answered. This research method involves modifying the independent variable and observing the effect of that change on the dependent variable (Cohen, *et al*., 2007; Ho, 2018). Specifically, the AR elements inserted into the lessons serve as the independent variable that is investigated regarding its impact on the 6th graders' listening performance.

4.1. The sample of the study

The recruitment of the participating students was not solely based on a probability sample, but also on convenience sampling, aiming to increase the reliability, comparability and transferability of the results. This approach ensured that each school, class and student had an equal chance to participate in this study, resulting in a representative and randomised selection within the broader population (Cohen *et al*., 2007; Ho, 2018). The procedure of random sampling demands a systematic sampling framework and is accomplished by dividing the population size by the desired sample size and then selecting a proportional fraction. Simultaneously, an essential criterion of sample selection was the present researcher's convenience in terms of geographical proximity, and easy accessibility, as well as the participants' availability at a specific period of time, and their willingness to volunteer. Needless to state, the participants needed to possess certain key traits that were directly related to the research aims (Dörnyei, 2007).

Consequently, the researcher randomly chose four Greek state primary schools from a total of forty schools in his area exhibiting similar characteristics regarding the location and student population. Each selected school had two or three classes of 6th graders, including from eleven to seventeen students. One class of 6th graders from each school were randomly assigned as the control group, while the remaining classes of 6th graders formed the experimental groups. As three classes of 6th graders were available at one of the four primary schools, the researcher randomly selected two of them as control groups and one of them as the experimental group.

Therefore, the present research was conducted across a total of nine classes. The sample comprises of one hundred twenty-two 6th graders, divided into sixty-two experimental students and sixty control ones. Concerning the gender distribution within the sample, it is observed that the 122 6th graders are divided into 43.4% (53) male and 56.6% (69) female students.

Furthermore, the majority of the participants were of Greek origin and monolingual, with a very small portion being of Albanian, Syrian, Bulgarian, and Russian origin, and bilingual. The 6th graders are at the age of twelve and they are grouped into classes alphabetically to minimise the risk of selection bias. According to the Common European Framework (CoE, 2001), 6th graders are at the A2 level. Three English teaching hours of forty-five minutes each are included in their weekly timetable. Moreover, the 6th graders have been exposed to the foreign language for the past five school years and they use the "English 6th Grade" Pupil's book and Workbook (Ευφραμίδου *et al.,* 2011). It can be argued that the characteristics of the research sample are representative of the typical profile of 6th graders in state primary schools in Greece.

The researcher selected the particular sample size to ensure the collection of sufficient data and, consequently, to draw reliable conclusions because statistical analysis of data requires a minimum of thirty participants, while a minimum sample size of fifty cases is needed to achieve statistical significance in the results (Cohen *et al*., 2007).

Additionally, every participant student was allocated a coded identification number, which was completed on the photocopies of the pre-test, post-test, and lessons. This technique safeguarded the participants' anonymity, and confidentiality, and ensured data linkability (Dörnyei, 2007). Specifically, the code was written in the form of S…EG…N… or S…CG…N…, denoting school (S), experimental group (EG), or control group (CG), and number (N), with the numbers duly filled in.

Except for the participating students, the four EFL educators responsible for teaching English in the nine classes across the four primary schools eagerly cooperated with the present researcher. The four EFL teachers, aged from forty-five to fifty-five years old, are Greek, monolingual, and possess a minimum of twenty years of teaching experience in state primary schools. Obviously, after the EFL teachers had given their consent to participate in the research, they were informed about the aims, objectives, content, and procedure of the research. Due to their unfamiliarity with integrating AR technology into the teaching of listening skills, they expressed concerns about teaching the research materials. Consequently, the researcher respected their anxiety and personally instructed the lessons to save time and secure reliable outcomes, as training them to use ARTutor4 would have been time-consuming.

4.2. The research tools

4.2.1. The pre-test and post-test

In line with relevant studies (Barreira *et al*., 2012; Hamdy, 2017) the researcher designed a pre-test and a post-test (Appendix I), administered them to the participants, and graded them. Throughout the development and implementation of the tests, the researcher endorsed the three guidelines suggested by Cohen *et al*. (2007). Firstly, the pre-tests and post-tests are used to evaluate the same content. Secondly, the control groups and the experimental groups received identical pre-tests and post-tests. Thirdly, the questions were designed to have graded difficulty levels, ensuring that they were neither too easy nor too difficult. During the tests and the instructional sessions, interactions were deliberately avoided among the classes of the students. The pre-tests aimed to verify the students' existing knowledge and compare it with their post-test performance after they had been instructed in the lessons, thereby identifying potential variations in the comprehension level of the dependent variables between the control groups and the experimental groups.

More precisely, the researcher designed a twenty-item pre-test to specify the participants' lexical recognition and knowledge, morphosyntactic parsing, and activation of their schemata at the outset of the research. All items of the pre-tests closely mirrored the content of the augmentations inserted in the listening lessons via ARTutor4. The twenty sentences in the 6th graders' pre-test include three answer choices, one of which is the correct answer. Moreover, the marking scheme ranges from score one, indicating very limited knowledge, to score twenty, representing the highest level of knowledge (Appendix I). The rationale behind this marking scale is to track the learners' progress rather than emphasise their mistakes. Finally, the pre-tests were administered to the 6th graders in their classrooms one month before the teaching of the research lessons commenced.

Furthermore, upon the completion of the research, the post-tests were administered to the same groups of students in their respective classrooms one month following the instruction of the teaching materials. The post-tests, mirroring the pre-tests in content and difficulty, were designed to trace any discrepancies in the proficiency levels of the experimental groups and control groups between the entry and exit points. Finally, during the statistical analysis, the post-tests scores of the dependent variables from the two groups significantly contributed to the determination of the impact of the quasi-experiment.

4.2.2. The teaching materials

The researcher has created three listening lessons for the control groups of the 6th grade, and their corresponding AR lessons for the experimental ones. Along with them, he has designed the introductory AR Lesson 1 exclusively addressed to the experimental groups. All lessons adhere to the tenets of the constructivist, sociocultural, and situated learning theories, the principles of the CEFR (CoE, 2001), and the methodology of the coursebook "English 6th Grade" (Ευφραιμίδου *et al.,* 2011). Moreover, they encompass adapted parts of Lesson 2 of Unit 3 of the coursebook titled "Do you believe in ghosts?". The accompanying audio recording, narrating a mysterious story in the form of the play titled "The fifty-cent coin" is also incorporated.

AR Lesson 1, titled "Welcome to ARTutor4", introduces 6th grade students to AR technology and the ARTutor4 application[1]. This initial lesson aims to familiarise learners with the functionality of ARTutor4, minimise technical difficulties, and ensure students focus on the content of subsequent lessons, thereby optimising learning time.

Lesson 2, designed for the control groups, is titled "The Fifty-Cent Coin – Scenes 1–3". It integrates language skills through pair-work activities such as multiple-choice comprehension questions, and sequencing images related to the story. These tasks engage students in activating prior knowledge, making inferences, and applying intensive listening, utilising both bottom-up and top-down listening processes.

For the experimental groups, the corresponding AR Lesson 2[2], incorporates identical activities with the inclusion of ten augmentations inserted through ARTutor4. The five audio files include sound effects, scene narration, grammar examples, note-taking tips, and listening strategies. Audio files vary in length from seven seconds to two minutes, providing interactive listening stimuli. Moreover, the five 3D models depict objects like a carriage, shelter, and fireplace to enhance vocabulary comprehension.

Lesson 3 for the control groups, titled "The Fifty-Cent Coin – Scenes 4–5", includes peer-cooperation tasks where students activate prior knowledge, listen to scenes 4–5, assign numbers, apply Geography knowledge, and work in groups to draft and perform dialogues. These activities integrate language skills, address learners' linguistic, cognitive, and kinesthetic needs, and foster creativity, communication, and collaboration.

The corresponding AR Lesson 3[3], includes the same tasks but integrates ten augmentations: five pictures, four videos, and one audio file. Pictures clarify word meanings and offer discussion tips, while videos provide geographic information and note-taking strategies, supporting cross-curricular and audiovisual skill development. Videos last from fifty to eighty-five seconds, and the audio file features scenes 4–5 of the play.

Lesson 4, "The Fifty-Cent Coin – The End!", addressed to control groups, incorporates collaborative activities designed to sequence plot summary, answer inferential questions, interpret the title of the play, and propose alternative titles. Additionally, students personalise the end of the play and create comics based on its plot, fostering imagination and expression.

Finally, AR Lesson 4 builds on these activities with ten augmentations: three videos, three pictures, three 3D models, and one audio file. These AR elements enrich the lesson through audiovisual plot

[1] Retrieved at https://artutor.cs.duth.gr/artutor/file/Text/1/9428b69355edf8ae.pdf
[2] Retrieved at https://artutor.cs.duth.gr/artutor/file/Text/1/bc3b513797104cf2.pdf
[3] Retrieved at https://artutor.cs.duth.gr/artutor/file/Text/1/03ebe835cde1e032.pdf

summary, a song on paragraph writing, a tutorial on U.S. currency, and visual aids for words like track and ruins, enhancing materials comprehension and motivation. AR lesson 4[4].

4.3. The AR application ARTutor4

ARTutor4 is an innovative platform that allows educators and learners to create augmented books by overlaying digital content onto specific parts of a physical or digital book. This content can include images, three-dimensional objects, audio recordings, videos, YouTube videos, and web links, enabling an interactive learning experience (Terzopoulos *et al.,* 2022). Based on the classification by Yuen *et al.* (2011), ARTutor falls under the category of AR book applications, offering a user-friendly solution for educators to integrate AR technology into their teaching practices.

One of the advantages of the application is its accessibility and ease of use. Registration for educational purposes is both simple and free, enabling educators to create as many AR books as they wish. The authoring tool requires no programming expertise, making it accessible to teachers with varying levels of technical proficiency. Augmentations for the books can be created using non-specialised software or sourced from publicly available materials, which further simplifies the process for educators.

Furthermore, ARTutor4 supports differentiated instruction by allowing teachers to design multiple versions of the same AR book. This flexibility enables educators to address diverse learner needs, accommodating various learning styles and abilities within the same classroom. Importantly, no registration is required for learners using the mobile application. Students can freely access AR books, ensuring an open and unlimited learning experience.

Finally, a notable advantage of ARTutor4 is its integration with conventional learning materials. Learners can interact with augmentations in both digital and printed formats of the book, allowing them to engage with digital enhancements without abandoning printed learning resources. This dual format preserves learners' familiarity of conventional textbooks while introducing innovative AR elements.

5. Research results

This section encapsulates the researcher's attempt to provide an answer to the research question: Do the students of the experimental groups of the 6th grade of state primary schools, who are taught the AR lessons, outperform the students of the control groups regarding their overall performance in listening in English? The answer is based on the data from the pre-test, post-test, and the three lessons, processed through various statistical tests.

5.1. The 6th graders' performance in the pre-test and post-test

No significant differences are observed in the performance of the experimental groups and the control groups of the 6th grade in the pre-test, as the experimental groups have *M*= 10.92, *SD*= 2.059, while the control groups achieve *M*= 10.40, *SD*= 1.861. Hence, it can be inferred that the 122 6th graders possess the same linguistic level. In contrast, the mean score of the experimental groups in the post-test is 15.45, while the mean score of the control groups is 10.93 (table 1). The progress from the pretest to the posttest for the experimental groups is approximately 41% (15.45/10.93), while the corresponding improvement for the control groups is merely 5% (10.93/10.40).

[4] Retrieved at https://artutor.cs.duth.gr/artutor/file/Text/1/03ebe835cde1e032.pdf

Test	Group	N	Mean	St. Dev.
Pre-test	Experimental	62	10.92	2.059
	Control	60	10.40	1.861
	Total	122	10.66	1.973
Post-test	Experimental	62	15.45	1.762
	Control	60	10.93	1.849
	Total	122	13.23	2.894

Table 1: Descriptive analysis for the two groups

The aforementioned findings are also documented by the tests of equality of mean values in table 2. The result of the pre-test $F(1,121)= 2.132$, $p= .147$ demonstrates that the F value does not hold statistical significance ($p= .147>.05$). On the contrary, the result of the post-test, $F(1, 121)= 191.001$, $p= .000$, indicates a statistically significant F value ($p<.05$).

Test	df	F	Sig.
Pre-test	df1=1, df2=121	2.132	.147
Post-test	df1=1, df2=121	191.001	.000

Table 2: Test of equality of means (ANOVA)

5.2. The 6th graders' performance in the lessons

Proceeding to the three lessons, the correlations between the performances are positive, statistically significant, and very strong. More specifically, all correlations surpass the threshold of 0.7, and the strongest correlation is between lesson 2 and lesson 3, $r(122)= .809$, $p= .000$. Moreover, the correlation of performance between lesson 2 and lesson 4 is $r(122)= .739$, $p= .000$, and the correlation between lesson 3 and lesson 4 is $r(122)= .707$, $p= .000$ (table 3).

LESSON		LESSON 2	LESSON 3	LESSON 4
LESSON 2	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	122		
LESSON 3	Pearson Correlation	0.809	1	
	Sig. (2-tailed)	0.000		
	N	122	122	
LESSON 4	Pearson Correlation	0.739	0.707	1
	Sig. (2-tailed)	0.000	0.000	
	N	122	122	122

Table 3: Correlation among the three lessons

In an effort to test the performance of the experimental groups and the control groups of the 6th grade, a test of equality of mean values was performed. The 62 students of the experimental groups achieve $M= 70.24$, $SD= 9.170$, which is significantly higher than the respective $M= 50.93$, $SD= 7.463$ recorded among the 60 students of the control groups (table 4). In other words, the listening performance of the experimental groups of the 6th grade is superior to the corresponding performance of the control groups.

Group	N	Mean	Std. Dev.	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Experimental	62	70.24	9.170	67.91	72.57
Control	60	50.93	7.463	49.01	52.86
Total	122	60.75	12.787	58.45	63.04

Table 4: Mean values of the two groups

Table 5 demonstrates that the F-statistic value of $F(1,121)= 162.109$, $p= .000$ is deemed statistically significant at the 1% level ($p<.01$).

	df	F	Sig.
Experimental vs Control	df1=1, df2=121	162.109	.000

Table 5: Test of equality of means (ANOVA)

In conclusion, the answer to the research question indicates that the AR- enhanced teaching intervention, received by the experimental groups of the 6th grade, led to a substantial enhancement of their overall listening performance in relation to the control groups.

6. Discussion of results

The research findings reveal that the AR-based teaching intervention applied to the 6th grade experimental groups resulted in a significant improvement in their overall listening performance compared to the control cohorts. This favorable outcome is corroborated by the previously mentioned statistical analyses, demonstrating that the experimental groups surpass the control groups in the post-test (section 5.1) and throughout the three instructional sessions (section 5.2). Both groups of the participants are shown to share the same linguistic level in the pre-test results.

By exploring how AR technology can enhance the listening skill of Greek primary school students, the present study addresses the gap identified by Parmaxi and Demetriou (2020), who note the scarcity of research on this specific skill. The only relevant study found by the present researcher is conducted by Barreira *et al.* (2012), who highlight notable improvements in English learning, particularly in oral word recognition, among primary school students using AR games.

Furthermore, qualitative data indicate a predominantly affirmative reception among the research participants. Observations conducted within the nine classrooms demonstrated that lessons enhanced by AR markedly elevated student motivation, engagement, cooperation, and vocabulary retention. One student stated, "*Using AR made learning English more fun because I could see and interact with objects instead of just reading about them.*" In a similar vein, an EFL teacher observed, "*Learners who typically encounter difficulties with English exhibited heightened enthusiasm and involvement during activities utilising AR*." Moreover, at the end of the research, all EFL teachers expressed enthusiasm and willingness to explore AR technology in their future teaching endeavors. Nonetheless, several students underscored technical obstacles, including device constraints and Internet connectivity, which briefly hindered lesson continuity. Notwithstanding these challenges, the overarching sentiment was that AR fostered a more immersive and efficacious educational environment, thereby underscoring the potential of this technology in TEFL classrooms.

Both the quantitative and qualitative results derived from the present study yield significant insights pertinent to the development of AR tools for other language skills and educational environments. The

heightened levels of motivation, concentration, and engagement documented indicate that AR technology can be efficiently implemented to cultivate interactive learning experiences in domains such as reading comprehension, pronunciation, writing, and syntax. For instance, AR applications have the potential to visualise narrative elements in real-time, thereby facilitating students' comprehension of plot development and character dynamics in foreign language acquisition. Additionally, the identified technical obstacles emphasise the necessity for user-friendly interfaces and offline functionality to guarantee accessibility in diverse educational contexts.

Finally, beyond TEFL, the propensity of AR to generate immersive educational experiences may benefit STEM education by enabling learners to investigate complex scientific principles through interactive 3D models or experience historical events via virtual field trips in the subject of History. Moreover, the positive impact on struggling learners suggests that AR-based tools could be adapted for special education, supporting students with learning difficulties through multimodal interaction. Overall, these findings underscore the potential of AR tools to enhance student-centered learning across various subjects and educational environments.

7. Limitations and future research

This study was exclusively conducted within state primary schools situated in a single municipality in Greece due to convenience sampling, which limits the generalizability of its findings. The distinctive educational, socioeconomic, and cultural context of this municipality partially influenced the results, indicating that the outcomes may not be entirely applicable to other regions characterised by divergent educational or socioeconomic environments. Additionally, in the context of private primary schools, where infrastructure and resources are typically more advanced, results may vary considerably.

To improve the representativeness of the sample, an ideal approach would entail conducting the study across a larger number of schools in different areas of Greece, thus enhancing the sample size and diversity of educational contexts investigated. Nevertheless, such an expansion was impeded by practical limitations, including the time required and the need for the researcher-led instruction in each participating school to guarantee consistent implementation of study materials, which is crucial for obtaining reliable data.

Furthermore, the scope of this study was limited to investigating the impact of AR technology on a single grade level for listening skill within primary education, which may restrict the applicability of its findings across various age groups or grade levels. The effectiveness of AR as a learning tool could vary significantly due to developmental differences, indicating that the outcomes identified in one grade may not necessarily be applicable to others.

Additionally, the research was exclusively centered on the enhancement of listening skill through the implementation of AR technology within the context of TEFL. Despite the promising results for this particular skill, these findings do not provide a holistic comprehension of AR's potential impact on other vital language skills, including reading, writing and speaking, which are integral to the language acquisition process.

To expand the understanding of the impact of AR technology on EFL learning, future research should be conducted across diverse regions characterised by varying socioeconomic and cultural backgrounds. Such an approach would not only assess the generalizability of the current findings but also facilitate a more profound exploration of the manner in which different geographical, educational and cultural contexts influence the effectiveness of AR-enhanced learning experiences.

Moreover, by incorporating a range of educational institutions in future studies, including private primary schools, private foreign language centers, state intercultural schools, and special education schools, researchers can gather valuable insights into the adaptability and impact of AR technology in heterogeneous educational settings. These institutions often cater to distinct student populations and may implement distinctive pedagogical approaches, rendering them significant environments for assessing how AR technology can be customised to meet specific learning needs.

Research on AR technology within the domain of EFL learning should encompass a broader range of grade levels in primary, secondary, and tertiary education. Such an approach would shed light on age-specific responses to AR-enhanced learning and provide critical insights into its effectiveness across a wider educational spectrum.

Another possibility for future studies could involve investigating the potential of AR technology to enhance a broader range of linguistic competencies, including reading, speaking, writing, pronunciation, vocabulary, syntax, and grammar. This exploration yields a holistic perspective on the role of AR applications in facilitating foreign language acquisition, moving beyond the focus on listening skill.

In conclusion, future research highlights the importance of continuous innovation in teaching methodologies. As technological advancements unfold at a rapid pace, educational practices must adapt accordingly to optimize learning experiences and effectively cater to the diverse needs of EFL learners in digitally enriched classroom environments.

8. Conclusion

To sum up, the integration of AR technology in educational settings has shown promising results, particularly in improving listening skills among 6th grade EFL students. By providing an immersive and interactive learning environment, AR technology can engage EFL students more deeply in the learning process, leading to significant improvements in their ability to comprehend and process spoken language.

Among the various AR tools available, ARTutor4 has demonstrated considerable promise as an effective resource for TEFL in Greek primary education. Its ability to create an engaging and interactive learning experience makes it a valuable asset in the classroom, helping young learners develop essential language skills in a way that is both enjoyable and pedagogical.

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Appendix I

PRE-TEST/POST-TEST

Circle a, b or c.

1. People travelled by ____last century.
   a. buses b. carriages c. bikes

2. You're welcome to take ____ at our hotel tonight!
   a. sleep b. room c. shelter
3. Every night my sister usually reads a book before she ____.
   a. gets up b. turns in c. turns up
4. Bikes aren't as expensive as cars means that cars are ____ than bikes.
   a. less expensive b. cheaper c. more expensive
5. When you take notes, you don't write a ____ text.
   a. full b. small c. short
6. Can you look at the smoke coming out of the chimney? That house must be __.
   a. fired b. abandoned c. warm
7. Watching a video without ____ can help you improve your listening skills.
   a. sound b. subtitles c. talking
8. The couple thanked the restaurant owner ____ he treated them their lunch.
   a. because b. while c. before
9. You look so ____! You need much sleep!
   a. tiring b. breathless c. exhausted
10. The Empire State Building is in ____.
    a. Spiegletown b. New York c. New England.
11. Spiegletown is a small town in (the) ____
    a. U.S.A. b. Great Britain c. New England
12. New England is in eastern ____.
    a. America b. England c. Great Britain.
13. When you take notes, please write down all the ____.
    a. details b. key ideas c. thoughts
14. When you discuss a topic with your classmates, you ____ and ____.
    a. don't interrupt / listen to the others' ideas b. are silent / think about your own ideas c. whisper / ask questions.
15. When a group cooperates, ____.
    a. some members work b. everyone takes a turn c. don't ask questions.
16. Let's follow this ____ to get out of the forest.
    a. street b. trunk c. track
17. The fire in the forest has left only ____.
    a. birds b. plants c. ruins
18. A paragraph starts with a ____.
    a. text b. phrase c. topic sentence
19. Please write the heroes' actual words of your comic in the ____.
    a. pictures b. word bubbles c. comic
20. Here's your change, sir! A ____ of two euros.
    a. banknote b. coin c. money

SCORE: ____ / 20

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