Development of virtual and augmented reality apps for language teaching: A case study

Desarrollo de apps de realidad virtual y aumentada para enseñanza de idiomas: Un estudio de caso

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ABSTRACT

Technological advances in recent decades and their increasing accessibility pose a constant challenge to teachers. This paper is based on our experience of using digital tools in language teaching, with a particular focus on German as a foreign language. The paper illustrates how we have responded to digital trends in education by gradually incorporating technological resources to facilitate students' acquisition of language knowledge and skills. In addition, the need to integrate such resources without having specific programming skills and without depending on the support of information technology (IT) staff encouraged us to explore and use development tools, turning us from technology users into developers of our own virtual (VR) and augmented reality (AR) apps. In this context, a case study of 72 university students is presented. The study analyses and compares the educational and motivational potential of the two apps developed by the authors using CoSpaces and ARTutor. The research instrument used was a questionnaire based on the technology acceptance model by Davis (1989), and the results were statistically analysed using SPSS V27. The results of the Wilcoxon test show the suitability and great potential of the developed apps, with no significant differences between them in terms of usefulness or motivational potential. The long-term use of these apps will allow us to analyse their impact compared to other resources, leading to the design of possible improvements.

Keywords: educational technology; new technologies; language teaching; university studies; case study.

RESUMEN

Los avances tecnológicos de las últimas décadas y su creciente accesibilidad, suponen para los docentes un reto permanente. El presente trabajo se basa en nuestra propia experiencia con el uso de herramientas digitales para la enseñanza de idiomas, concretamente para el alemán como lengua extranjera. Se muestra cómo hemos respondido a las tendencias digitales de los últimos años en el ámbito educativo, incorporando progresivamente recursos tecnológicos para facilitar a nuestros estudiantes la adquisición de conocimientos y destrezas lingüísticas. Integrar estos recursos, sin tener conocimientos de programación y sin el constante apoyo de personal informático, nos ha llevado a explorar y usar herramientas de desarrollo, convirtiéndonos de usuarios de las tecnologías en desarrolladores de nuestras propias apps de Realidad Virtual (RV) y Realidad Aumentada (RA). En este contexto, se presenta un caso de estudio llevado a cabo con 72 estudiantes universitarios, en el que se analiza y compara el potencial educativo y motivador de dos apps creadas recientemente por los autores de este artículo con CoSpaces y ARTutor. Como instrumento de investigación se utilizó un cuestionario basado en el Technology Acceptance Model de Davis (1989), realizando con SPSS V27 un análisis estadístico de la información obtenida. Los resultados manifiestan la idoneidad y el enorme potencial de las apps desarrolladas, no existiendo entre ellas diferencias significativas con respecto a la utilidad o al potencial motivador (Test de Wilcoxon). El uso prolongado de estas apps nos permitirá analizar su impacto frente a otros recursos y diseñar las posibles mejoras.

Palabras clave: tecnología de la educación; nuevas tecnologías; enseñanza de idiomas; estudios universitarios; estudio de caso.

INTRODUCTION

Technological advances in recent decades and their increasing accessibility have changed, and in many cases even revolutionised, the way we live, work, interact and communicate. Concepts such as artificial intelligence (AI), big data, algorithms, e-learning, facial recognition, digital citizenship, quantified self, ChatGPT and the metaverse have inundated our daily lives.

The potential of digital technologies, which focus on reducing and overcoming obstacles related to time, distance and/or space, is key in improving all areas of society in this process of constant change.

In this sense, international organisations such as UNESCO (2018), the European Union and the UN (2019) have reiterated, on numerous occasions, the need to promote the integration of digital technologies to advance not only work-related, personal or educational areas but also sustainable global development. Finding inclusive solutions and developing digital literacy have become priorities (García Aretio, 2019).

For centuries, education has been characterised by face-to-face teaching, with teaching–learning resources based on manuals and paper-based materials. However, technological advances and the trend towards the use of new resources have hastened the revolutionising and diversifying of teaching and learning models. Moreover, the recent pandemic and global stay-at-home orders have made the need for such digital transformations more visible than ever (López-Belmonte et al., 2023; Zalite & Zvirbule, 2020).

In analysing the technological and digital evolution of recent years, we can see that the creation of Web1 in 1989 and its extended versions (Web2, Web3 and Web4) have opened up a wide range of possibilities for creating new environments based on interaction, collaboration and co-creation between users (Tavakoli & Wijesinghe, 2019), as well as a wide range of possibilities for personalising content.

In this context of technological expansion, new teaching–learning models are being developed and consolidated. Concepts such as e-learning, blended learning (*b-learning or blended learning*) (Souabi et al., 2021), with its best-known pedagogical model, the flipped classroom (López-Belmonte et al., 2021), mobile learning (*m-learning*) (Lazar & Milena, 2013), ubiquitous learning (*u-learning or ubiquitous learning*) (Aljawarneh, 2020) and adaptive/personalised learning (Xie et al., 2019) have become popular topics of research and discussion. At the same time, other technologies are gaining importance:

- E-learning platforms or learning management systems (LMSs) (e.g., Claroline, WebCT, Blackboard, Moodle and Sakai) (Dobre, 2015).
- Interactive apps, commercial video games and educational video games (serious games) that promote entertainment, mass and online interaction and even gamified learning (Jabbari & Eslami, 2019; Peterson, 2016).
- Social networks (e.g., Facebook, Twitter, Instagram and YouTube), which enable communication and the sharing of information (Chartrand, 2012).
- Virtual environments and worlds that configure these new scenarios (Active World, Second Life, etc.), fed by the peculiarities and advantages of mass and online video games (Molka-Danielsen & Deutschmann, 2009).

At the same time, numerous development tools have emerged for the creation of platforms, apps, video games or virtual environments through which educational

materials can be shared. Such development tools, initially commercial and aimed at professionals with programming skills but now offered as free or low-cost alternatives, allow for the creation and design of content and materials adapted to the needs of end users without computer skills (Terzopoulos et al., 2021; Vert & Andone, 2019). Digital technologies and tools, that offer different alternatives, are all characterised by their potential for creating new teaching–learning environments as well as new forms of interaction and learning enhancement.

Today, platforms such as Moodle and Blackboard have been well established. The use of audiovisual resources (podcasts, audio and video) and communication via platforms and social networks has become a reality. Every Moodle includes links to video conferencing apps (*Meet, Zoom* or *BigBlueButton*) and allows the sharing of a wide range of resources (text documents, multimedia presentations, video, audio, web pages, blogs, etc.). However, technological developments applicable to the field of education, especially university education, are much broader, especially with the development of virtual reality (VR) apps (Parmaxi, 2023) and, more recently, augmented reality (AR) or mixed reality (MR) apps (Parmaxi & Demetriou, 2020). The incorporation of chatbots, AI-based software capable of simulating real-time conversations (Neumann et al., 2021) or the metaverse, as an environment in which the real and virtual worlds (VWs) coexist, allowing users to move between them simultaneously (Aydin, 2023; López-Belmonte et al., 2023), are here to stay and will become part of the educational process sooner or later.

Technological advances and the creation and expansion of new teaching and learning models and tools have also impacted language teaching. An important milestone in this respect has been the introduction of virtual learning environments (VLEs)/LMSs and the creation of VWs. While the former provide many different tools for individual learning (text documents, multimedia resources, etc.) and collaborative learning (blogs, forums and wikis), the latter offer the possibility of designing environments that are usually difficult to recreate in the classroom and that, in addition, allow for language immersion outside the classroom.

Some implementations, such as those described by Canto et al. (2014), Molka-Danielsen and Deutschmann (2009) and Jauregi and Canto (2012), are examples that highlight the potential of VWs in strengthening learners' oral and intercultural competence. Other authors, such as Melchor-Couto (2017), have also highlighted their ability to reduce factors such as anxiety, which is prevalent among second-language speakers and usually hinders their language acquisition process (Krashen, 2003). Being able to communicate in VWs through an avatar and, therefore, avoiding physical exposure to other speakers, contributes positively to reducing such anxiety for many learners.

Balderas et al. (2017) and Palomo-Duarte et al. (2018) have highlighted the potential of VWs to provide learners with valuable opportunities for target language interaction, collaborative learning and the development of communicative competence. The implementations developed by these authors highlight the benefits of combining two different tools, such as video games and VWs, and exploiting the specificities of each to enhance learning.

Thus, computer-assisted language learning (CALL), which initially focused on the user's interaction with the computer and the software, or learning websites, is being increasingly enriched by the integration of new tools (chat, email, audio and video conferencing programmes, etc.) that facilitate interaction and communication with other speakers of the target language (Levy & Stockwell, 2013).

The growing access to new devices (e.g. mobile phones, tablets, smartphones, VR and AR glasses) and the trend in digital education to use cutting-edge technologies to make learning more attractive and adapt it to learners' pace and lifestyle have contributed to the creation and gradual consolidation of other methodologies, such as mobile language learning (MALL) and language learning through VR (VRALL) and AR (Burston & Giannakou, 2022; Heil et al., 2016; Parmaxi & Demetriou, 2020).

Methodologies such as CALL have greatly increased the number of valuable opportunities to facilitate learners' access to a wide variety of learning resources. However, the use of increasingly sophisticated mobile devices, and later, VR and AR glasses, have further extended and facilitated such learning opportunities, whether through interaction and collaboration with other users (SMS, voice and audio calls) or through interaction with immersive learning environments. In addition, the use of mobile devices has enabled increasingly ubiquitous learning, facilitating access to any material, at any time and from anywhere (Hua & Wang, 2023; Karakaya & Bozkurt, 2022; Kukulska-Hulme & Viberg, 2018).

Despite the enormous potential of VWs and apps designed to capitalise on VR and AR in language teaching, many difficulties are associated with their use and implementation. Czepielewski et al. (2011), Garrido-Iñigo and Rodríguez-Moreno (2015), Palomo-Duarte et al. (2018) and Jauregi-Ondarra and Canto (2022) have highlighted the main drawbacks of using VWs as a teaching and learning tool:

- A powerful server that can ensure a stable connection and good functioning of the VW is needed.
- Information technology (IT) support is required in designing and maintaining the VW and the resources created in it and in monitoring the students and their learning processes.

When it comes to the use of VR and AR, a large number of apps on commercial platforms such as Google Play and the App Store and many other tools allow VR and AR environments to be designed without the need for computer support (Terzopoulos et al., 2021), although they present new difficulties:

- Development software is often incompatible with different operating systems and device versions.
- Much of the current development software that is available for free and easy to use is very basic, with the full version still costing a lot of money.

This work, framed in the context of university teaching, is based on our own teaching experiences. During the last decade, learning to teach has been a challenge. Technological advances and the integration of technology into the university classroom have allowed us to develop digital resources that are partially or fully integrated into the course of academic activity. In just a few years, we have moved from the master class to blended learning, the flipped classroom and collaborative, ubiquitous, personalised and meaningful learning, where the student has become the main and essential actor in the process. Factors such as attitude and motivation are of great importance in achieving learning goals. Bringing the classroom closer to the student's daily reality, to the environment and context that the student knows, manages and is familiar with, both cognitively and affectively, greatly facilitates the learning process. Student-centred learning, using real and tangible contexts, allows for situated and

contextualised teaching, which facilitates the acquisition of all the skills, abilities and knowledge required by the curricula.

Today's educational processes need to adapt to these changes and make use of the technological resources available to facilitate and promote lifelong and inclusive learning. However, there are many situations in which the teacher is not prepared to manage such resources or the resources have not been adapted to their needs (Romano et al., 2020) or to the needs of the curricular design. In addition, the integration of these tools often requires an extraordinary amount of time and additional effort, and the benefits of such tools are not always known *a priori*. If we add to this reality the still-existing digital divide, basic ethical principles, such as equal opportunity, and the usefulness, accessibility or scalability of technologies, we find ourselves at the nexus between technological possibility but methodological difficulty. In other words, we find ourselves in a technological world that is advancing at a faster pace than digital education and, of course, at a faster pace than we are ourselves.

DIGITAL EDUCATION IN LANGUAGE TEACHING

Teaching Experience

Today, many language teachers have incorporated digital technology into their teaching, and there are many research studies on the subject. However, it is difficult to determine which are the ideal tools and resources for those who want to learn a language. It is no easier to find such tools for those who teach a language, as many of the commercial resources available do not allow their content to be adapted or implemented to meet teaching and learning needs (Heil et al., 2016). Technological development in the last two decades and our concerns as teachers have led us to gradually explore the use of different technologies, tending to incorporate as many tools as possible to speed up learning as long as it was methodologically and pedagogically possible. However, we have been limited by our ability to design and create them.

Moodle allowed us to supplement our classroom teaching with a wide range of additional materials and resources for self-directed learning outside the classroom. These materials mainly comprise multimedia resources (interactive exercises with integrated feedback, podcasts, videos with native speakers, etc.) and the use of collaborative tools such as forums, chats and glossaries. While the former allowed us to provide our students with important resources to enrich their linguistic input, the latter allowed us to provide them with tools to use and practise the target language by making videos with other classmates and sharing them via a forum with the teacher and other course participants. Although our students' acceptance of these new teaching and learning resources was very positive, as were the results in terms of the language acquisition process, we soon felt the need to explore other environments. This need arose primarily from the attempt to extend the language acquisition process initiated in the classroom to learning outside of the classroom.

In this sense, VWs offered us the opportunity to create learning environments that were not only more attractive, dynamic and interactive than those offered by Moodle or other LMSs but also more similar to the environments in which our learners usually immerse themselves in their free time (video games, online environments, etc.). However, the implementation of VWs that responded to our teaching needs required IT support for their design and administration. Our first experiences with using and

implementing VWs were therefore characterised by close collaboration with colleagues and experts in software development. Together, we designed our first video game, the *Supermarket-Game,* in which students have the opportunity, through different individual and competitive activities, to acquire vocabulary related to the products found in a supermarket and then to make a virtual purchase from the list of available products (Figure 1) (Berns et al., 2013).

Figure 1
Supermarket-Game

As a result of to the positive impact of the game on both motivation and student learning, we set out to further explore the potential of VWs to create and implement more collaborative environments. This led to the creation of a shop (*Saturn-Game*), a house (*Hidden-Room Game*) and a cafeteria (Figure 2. *GEFE-Game*). Interaction between players or with a bot in the case of the *GEFE-Game* took place via text chat, a feature that was enabled in each of the games.

Figure 2
GEFE-Game

The high potential of such environments to encourage the use of and interaction with other target language speakers was tested in case studies over several academic years with A1-level German learners at the University of Cádiz (Palomo-Duarte et al., 2018).

The constant development of mobile technologies, together with the spread of smartphones among our students, soon encouraged us to explore new learning environments based on m-learning. The first environment developed was an app called VocabTrainerA1, which focuses on students' acquisition of vocabulary and grammar while enhancing their comprehension, written expression and communicative

competence. This environment combines several individual mini-games with a collaborative role-playing game (*Catch me if you can!*) in which players must use previously acquired language skills to jointly catch—through a role-playing game—a serial killer before he commits his next crime. The interactions that occurred on this collaborative app were collected as data on the server hosting the app, allowing us to analyse each student's participation and learning process.

To foster students' acquisition of not only language skills and content (vocabulary, grammar, written comprehension and expression) but also cross-curricular skills (analytical critical thinking or teamwork through peer assessment), we developed a second app, called *Guess it! Language Trainer*. This app provides a gamified and highly dynamic environment based on community learning, which allows the user to both acquire new linguistic input (vocabulary, grammar and language structures) and apply it by creating and adding new content to the app. *Guess it! Language Trainer* is based on a client–server architecture, in which the server coordinates multiple mobile devices. The server's connection to the network and the system makes it possible to identify each user's interactions with the app and to store the data on the teacher's web portal, allowing the teacher to identify any difficulties the students may be having and to evaluate their learning process.

The asynchronous interactions enabled by *Guess it! Language Trainer* led us to design *Terminkalender* as an app model that would allow greater interaction and collaboration between users and, above all, synchronous communication between multiple users in a client–server architecture (Isla-Montes et al., 2022).

To explore the possibilities of immersive environments created through the use of 360° videos and the implementation of a chatbot, we developed the *Let's date!* VR app.

The use of a chatbot allowed us to offer learners new opportunities for language immersion and near-real interaction in the target language, although it cannot completely replace human-to-human interactions. In our *Let's date!* design, a scenario (a dating agency) was recreated using multiple spherical recordings, giving learners the opportunity to immerse themselves in a 'real world' while interacting with 'real people' (a dating agency employee). The app was developed using Visual Environment for Designing Interactive Learning Scenarios (VEDILS), a development tool that, although designed for non-computer scientists (Baena-Pérez et al., 2022), requires basic programming skills.

Figure 3
Let´s date!

Despite the enormous potential of the aforementioned technologies implemented in our classrooms, we encountered many difficulties as non-IT teachers. The foremost difficulty was the constant dependence on IT staff to develop, implement and ensure the proper functioning of any app based on the use of advanced technology (AT). This soon led us to look for more sustainable solutions (i.e., tools capable of facilitating and speeding up both the creation and implementation processes inside and outside the classroom). In this regard, the increasing proliferation and availability of open source apps and development tools (Terzopoulos et al., 2021; Vert & Andone, 2019) provided us with valuable opportunities to easily create VR and AR environments aligned with our teaching needs.

LANGUAGE TEACHING WITH VIRTUAL REALITY AND AUGMENTED REALITY

The Current Challenge

Our previous experience in implementing virtual environments has informed our appreciation of their potential for language teaching, not only giving us new opportunities to create highly immersive and interactive environments but also to make them meaningful and attractive to our students, who are accustomed to the use of AT in their everyday lives. The desire to easily design and implement new environments led us to evaluate development tools to work with. Among the different tools we evaluated, we finally chose CoSpaces[1] and ARTutor[2], which allowed us to move from being users of platforms and apps designed by software development experts to being developers of our own VR and AR apps. As non-IT teachers, it was a challenge to design VR and AR apps. Additionally, as language teachers, it was a challenge not only to create tools that facilitate the learning of the target language but also to get a positive response from the students.

The VR app designed using CoSpaces and the AR app designed using ARTutor are described below, along with the results obtained by implementing, evaluating and comparing them in a case study carried out at the University of Cádiz.

Description of the VR App Built with CoSpaces

The designed VR app (*360º-Sightseeing Tour*) features 22 360º panoramic views, short text files and audio recordings whose aim is to facilitate students' acquisition of different content and language skills (vocabulary acquisition and improvement of oral and written comprehension) through a virtual tour of characteristic places in the city of Cádiz (squares, parks, theatres, cafés and bars, buildings, etc.). The choice of the different scenes that make up the virtual tour is based on the themes and linguistic content included in the curriculum and in the Common European Framework of Reference for Languages (CEFR) for learners at level A1 (e.g., vocabulary related to the place of residence, daily life and leisure activities).

Once downloaded to their mobile devices, learners can work to acquire the target language by interacting with the VR app through the text and/or audio information points created for each scene (Figure 4).

Figure 4
Example of a panoramic view with information points in the 360º-Sightseeing Tour app

Description of the AR App Built with ARTutor

ARTutor, a completely free development tool, allowed us to create *Who am I?* based on a guessing game where students have to describe and guess different characters from a photo. It consists of 20 AR markers hiding photos of different famous people (YouTubers, actors, athletes, etc.).

The activity was designed to correspond to one of the thematic blocks of the subject German I, which focuses on vocabulary related to the professional and personal environment, covering topics such as professions, hobbies, personality or physical appearance. The aim of the activity is to encourage students to practise the vocabulary they had previously worked on in class while developing their oral comprehension and expression.

After downloading the app to their mobile devices, the students worked in pairs, which changed in the different rounds of the game, to describe and guess the characters of their respective AR markers (Figure 5).

Figure 5
Examples of the AR app Who am I?

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Aim of the Study

The study aimed to analyse the educational and motivational potential of the VR and AR apps (as examples of digital resources that can be developed without any IT support) among university students. Our inquiry was guided by the following questions:

Q1. Do VR and AR environments, such as those created using CoSpaces and ARTutor, facilitate students' learning?

Q2. How do students evaluate the motivational potential of VR and AR environments?

Q3. Do students' perceptions of the VR app match their perceptions of the AR app?

Study Participants

A case study was carried out with 72 students studying German at the A1 level at the Faculty of Humanities at the University of Cádiz. To be selected for inclusion in the sample, the participating students had to use the developed apps autonomously in at least one session, independently of the one used jointly to familiarise themselves with the apps. A total of 72 students provided their feedback on *360°-Sightseeing Tour* and 70 provided feedback on *Who am I?* Such feedback was used in subsequent analyses.

Research Method and Design

The research method can be summarised in four steps. The first focused on the selection and design of the appropriate instruments to collect feedback from students about their user experience while learning German using *360°-Sightseeing Tour* and *Who am I?* The second focused on data collection and, finally, the third and fourth were dedicated to the analysis of information using statistical techniques that led us to preliminary conclusions and ruminations of their consequences for future implementations.

Research Instrument

A user experience questionnaire based on the technology acceptance model (TAM) (Davis, 1989; Romano et al., 2020) was adapted to our study to observe the students' perceptions in reference to four fundamental aspects: the perceived ease of use (PEU), perceived enjoyment (PE), perceived usefulness (PU) and the intention to use (IU).

The adapted questionnaire (see Table 1) was designed using a 7-point Likert scale (1 = strongly agree, 2 = agree, 3 = more or less agree, 4 = undecided, 5 = more or less disagree, 6 = disagree and 7 = strongly disagree).

Table 1
TAM adapted questionnaire

Items	Description
PEU1	Understanding how to operate the app is easy.
PEU2	Learning how to operate the app is easy.
PEU3	Remembering how to operate the app is easy.
PEU4	Being an expert in the app would be easy for me.
PEU5	Reading the information on the display is easy.
PEU6*	Oral explanations are easy to understand.
PEU7	Overall, I find the app easy to use.
PU1*	The use of the app helps to understand the content and vocabulary very quickly.
PU2	The app increases my attention to the content of the lesson.
PU3	I think that after using the app, I will get better results in the vocabulary test.
PU4	I believe that after using the app, I will get better results in answering the questions on the topic.
PU5	After using the app, I have learned more vocabulary.
PU6	After using the app, I have learned more about the topic in general.
PU7	The app helped me gain a deeper understanding of the topic.
PU8	The app facilitates vocabulary learning.
PU9	Overall, I find the app more useful for learning.
PE1	The app makes learning more fun.
PE2	I enjoyed exploring the designed environment while using the app.
PE3	Doing the activity is captivating.
PE4	Overall, I enjoyed using the app.
PE5	Overall, I think the app was exciting.
IU1	I would like to have this app to learn more language topics.
IU2	I would use this app to learn foreign languages.
IU3	I would recommend the app to other language students.

*Not requested in the analysis of *Who am I?* (AR with ARTutor)

Data Collection

The information obtained was translated into the following variables to be studied: app used (VR or AR), PEU (PEU1 to PEU7), PE (PE1 to PE5), PU (PU1 to PU9) and IU (IU1 to IU3). The information collected was processed for statistical analysis using SPSS V 27.

Analysis and Results

First, there was a high degree of homogeneity among the responses of the 72 participants, as indicated by their quasi deviations ranging from 0.459 (PU1) to 1.254 (IU1) on a measurement scale ranging from 1 to 7. Although these data led to a maximum error in the interval estimation for the mean response of each variable, ranging from 0.109 to 1.2988, an error that can be considered sufficiently small with 95% confidence, it would have been preferable to have included a larger number of participants in our study.

In response to the first question posed (Q1), students agreed that the biggest advantage of both *360º Sightseeing Tour* and *Who am I?* is the opportunity to learn more (PU7) and faster (PU1). Table 2 summarises the overall results obtained with regard to the learning potential and usefulness of the apps, from 49.86% of the students considering the VR app to be very useful (56.07% in the case of the AR app)

to more or less useful (10.68% for the VR app and 6.07% for the AR app). None of the participants thought they were either not very useful or useless.
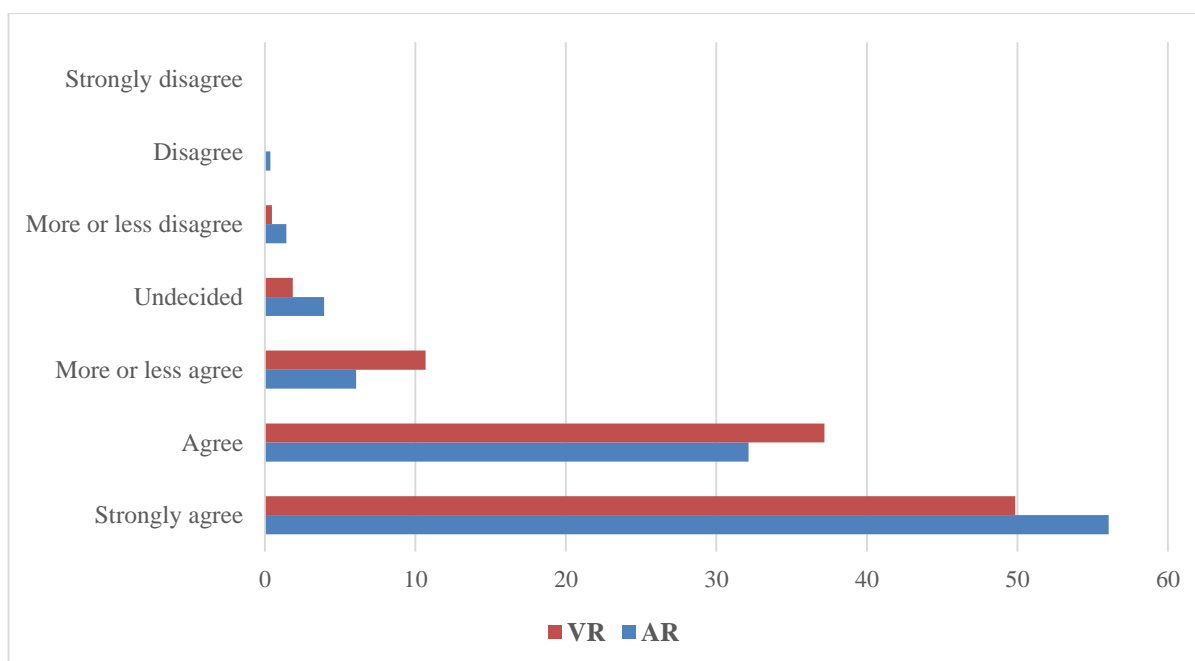
Table 2
Results of the apps' usefulness

Perception of its usefulness	360º-Sightseeing Tour - VR		Who am I? - AR	
	Percentage	Accumulated percentage	Percentage	Accumulated percentage
Strongly agree	49.86	49.86	56.07	56.07
Agree	37.17	87.02	32.14	88.21
More or less agree	10.68	97.70	6.07	94.29
Undecided	1.84	99.54	3.93	98.21
More or less disagree	0.46	100.00	1.43	99.64
Disagree			0.36	100.00
Strongly disagree				

Source: own elaboration from the results obtained with SPSS V27.

In summary, 97.70% and 94.29% of the participants considered the VR app and the AR app, respectively, valid for learning (cumulative percentage regarding their usefulness based on the percentage of participants who responded totally agree, agree and more or less agree). Figure 6 illustrates the results of this analysis.

Figure 6
Student perceptions of the apps' learning potential

Source: own elaboration from the results obtained with SPSS V27.

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The motivational potential of the two apps analysed (Q2) is revealed through the results collected in Table 3 and presented in Figure 7:

- Regarding PEU, the VR app was even easier and more user friendly than the AR app; 97.64% said *360º-Sightseeing Tour* was easy to use, while 91.25% considered *Who am I?* easy to use.
- Regarding PE, the vast majority of students scored all PE-related items between 1 and 3 on the Likert scale, meaning 94.60% of students enjoyed using *360º-Sightseeing Tour* and 97.99% enjoyed using *Who am I?*
- Regarding IU, 92.40% would recommend or use *360º-Sightseeing Tour* for language learning and 98.19% would use *Who am I?*

Overall, both apps seemed to foster the same level of motivation; 94.88% of the participants who used *360º-Sightseeing Tour* and 95.81% of the participants who used *Who am I?* found these tools to motivate language learning, highlighting their fun, dynamic and interactive character, which makes learning exciting and engaging, as well as easy.

To extend this analysis for the sake of future decisions, we compared the differences between the apps with respect to their educational and motivational potential, responding to Q3. The Wilcoxon test (Table 4) led us to conclude that there were no significant differences in perceptions regarding these apps' usefulness (P-value = 0.9063) or in any of the aspects that make up the motivational potential (P-values = 0.2429, 0.2394 and 0.932 for PEU, PE and IU, respectively). If we consider the potential of the tools as a whole, no significant differences were detected (P-value = 0.961).

Table 3
Results of the apps' motivational perception

| Motivational perception | 360°-Sightseeing Tour - RV | | | | | | | |
| | Ease of use (PEU) | | Enjoyment (PE) | | Intention to use (IU) | | Motivational perception (PEU+PE+IU) | |
	Percentage	Accumulated	Percentage	Accumulated	Percentage	Accumulated	Percentage	Percentage accumulated
Strongly agree	59.99	59.99	49.60	49.60	54.17	54.17	54.59	54.59
Agree	28.96	88.95	35.82	85.42	29.20	83.37	31.33	85.91
More or less agree	8.69	97.64	9.18	94.60	9.03	92.40	8.97	94.88
Undecided	1.50	99.14	3.34	97.94	2.80	95.20	2.55	97.43
More or less disagree	0.57	99.71	2.06	100.00	2.80	98.00	1.81	99.24
Disagree	0.29	100.00			0.00	98.00	0.10	99.33
Strongly disagree		100.00			2.00	100.00	0.67	100.00
	¿Who am I? - AR							
	Ease of use (PEU)		Enjoyment (PE)		Intention to use (IU)		Motivational perception (PEU+PE+IU)	
	Percentage	Accumulated	Percentage	Accumulated	Percentage	Accumulated	Percentage	Percentage accumulated
Strongly agree	57.50	57.50	63.59	63.59	65.76	65.76	62.29	62.29
Agree	22.19	79.69	27.61	91.21	25.01	90.78	24.94	87.22
More or less agree	11.56	91.25	6.78	97.99	7.41	98.19	8.59	95.81
Undecided	3.13	94.38	1.10	99.09	1.39	99.57	1.87	97.68
More or less disagree	2.50	96.88	0.82	99.91	0.42	99.99	1.25	98.93
Disagree	1.88	98.75	0.07	99.98	0.01	100.00	0.65	99.58
Strongly disagree	1.25	100.00	0.02	100.00			0.42	100.00

Source: own elaboration from the results obtained with SPSS V27.

Figure 7

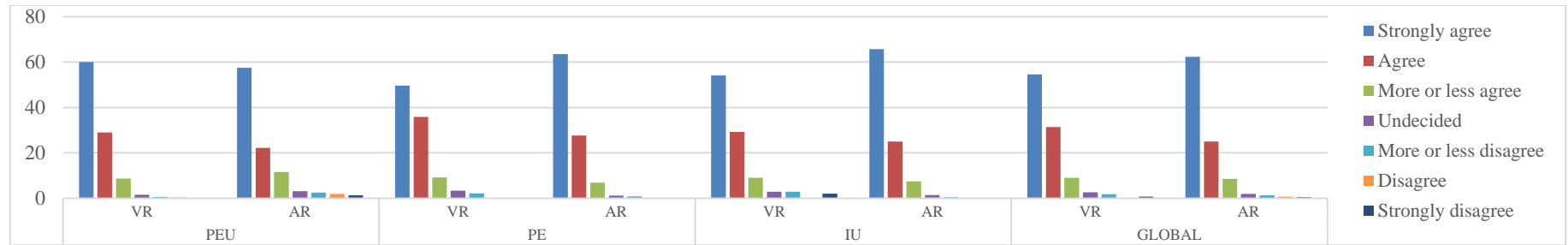Comparative representation between the potential of both apps

Table 4

Wilcoxon test to compare the perception of VR and AR

	Statistical value (V)	P-Value	Significant differences
Perceived usefulness (PU)	37	0.9063	No
Perceived Ease of use (PEU)	81.5	0.2429	No
Perceived Enjoyment (PE)	137	0.2394	No
Intention to use (IU)	62	0.932	No
Overall potential	1181.5	0.961	No

Source: own elaboration from the results obtained with SPSS V27.

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CONCLUSIONS

In an increasingly globalised and diverse society, where students have easy access to many digital resources, effective and engaging learning is essential. The dynamic and interactive nature of the developed technologies and tools helps engage students and motivates them to learn and, in our case, practise the target language.

The results obtained in our study in response to the questions raised (Q1, Q2 and Q3) show the suitability and enormous potential of the apps developed, reaffirming the need to digitalise teaching to improve the teaching–learning process. Being able to develop apps that, according to our own students, facilitate learning and the acquisition of the skills that mastering a language requires, encourages us to continue working in this line.

As the study shows, the type of technology used alone does not determine the educational and motivational potential of digital resources. Deciding how, when and why to integrate technology into our teaching is important, not only to engage students in learning and make it more enjoyable and dynamic but also to prevent negative side effects (Southgate et al., 2019). Balancing the risks and benefits of digital education, even more so with the constant incorporation of cutting-edge technologies, is necessary for the coexistence of traditional learning methods and technology in the teaching process. In this context, the semi-immersive, exploratory and participatory nature of the developed apps, *360°-Sightseeing Tour* and *Who am I?,* as well as their ease of accessibility through devices such as smartphones or tablets, make them suitable for involving students in their learning, as such apps make learning more dynamic and comprehensible. The development tools, both CoSpaces and ARTutor, are easy to use and do not come with additional financial costs. Furthermore, they contribute to and respect the accessibility and scalability of digitisation.

Finally, it is necessary to improve the analysis of the academic impact and effectiveness of the developed apps by involving a greater number of participants in the experience to ensure the external validity of the conclusions. Given the recent creation of the apps, the 2023–2024 academic year offers the perfect opportunity to prolong the use of these tools and to carry out comparative studies that will allow us to analyse their impact compared to other resources, as well as to design possible improvements.

NOTES

[1]. http://cospaces.io/edu/
[2]. http://artutor.ihu.gr/home/

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