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Virtual and Augmented Reality Applied to the Perception of the Sound and Visual Garden

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Abstract: The COVID-19 situation has encouraged the creation of ICT-based learning environments. Difficulties in performing activities in a garden setting can be overcome by using Virtual Reality (VR) and Augmented Reality (AR). The aim of this research is to evaluate the usefulness of VR and AR as an educational resource through contextualised sensory experiences in the garden. Eighty-seven trainee teachers took part, and a mixed methodology was used, for the analysis of the sound and visual elements of the garden and for reflection on the usefulness of VR and AR. An interpretive and inferential analysis of the AR-based compositions was carried out and of the drawings of the garden created by the participants after the virtual immersion. The results show a bucolic-pastoral vision of the garden with a predominance of natural elements and a human presence that is respectful of the natural environment. During the immersion, >90% of the participants indicated that the sensations were positive and were able to distinguish natural components from human and/or technological items. The role of VR and AR in enhancing the understanding of content is notable, being, at the same time, tool, resource and content, which reinforces the idea that they can favour the development of teaching and digital competences.

Keywords: sound and visual garden; virtual learning environment; augmented reality; virtual reality; teacher training

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1. Introduction

Since COVID-19 restriction measures were introduced in Spain, it has not been possible to carry out many outdoor learning activities, depriving learners of the opportunity to benefit from their many advantages. A garden-based school has found itself in this same situation, with limitations on the normal operation of its activities. However, according to Ceballos et al. [1], even under lockdown and studying alone at home, learners have acknowledged the potential of gardens for developing values and an inquisitive attitude, including interest in Environmental Education. At the same time, this emergency situation has encouraged a change in teaching practices by creating learning environments based on ICT [2].

Faced with this situation, the following questions arise: Is it possible to carry out these garden activities virtually? If so, what type of activities can be designed to achieve a quasi-realistic likeness of the garden environment? To answer these questions, we must first analyse the advantages of the Garden-Based Learning (GBL) model and then decide on the type of ICT resources that can be used to effectively "virtualise" the garden.

Naturalising the school environment is a priority in encouraging children's contact with nature. Outdoor education not only helps learners to be in harmony with their surroundings and makes them appreciate the natural world but also plays an important role in transferring what they learn in the classroom to their everyday lives through observing and applying it, while it also contributes a great deal to their personal, emotional and social development [3,4]. This approach to nature increases their curiosity, experimentation and motivation [5] and, at the same time, improves their learning of the values, attitudes and a respect for nature as it develops an authentic and lasting environmental awareness [6]. In this regard, school gardens have various contexts for bringing children closer to the natural environment and engaging them in experiential learning [7].

The benefits of school in a garden setting are many. For one thing, it is an educational resource that can improve the perception of the complexity and the systemic character of nature [8]. At the same time, it is a context for multidisciplinary and interdisciplinary learning that assists in linking scientific and artistic disciplines [9,10]. What is more, field activities and practices can be considered tools for the teaching of sciences that favour the use of specific procedures, skills and competences, enabling scientific problems related to biology to be solved [11,12]. According to Caamaño [13], this kind of activity enables the integration of theory with practice; the understanding of the construction of scientific knowledge and the acquisition of scientific skills such as observation, interpretation and the operation of measurement instruments. Muñoz and Carmona [14] pointed out that field practice is a resource for enabling a reinforcement of the knowledge associated with biology and that it can potentiate certain aspects of the performance as future teachers [15,16]. Some recent studies have focused on describing these experiences, analysing the strengths, difficulties and their impact on the development of professional competences in future teachers [17,18] and, particularly, in Education for Sustainability [7,19–21].

At an emotional level, experiences with nature can encourage learning by bringing improvements in learners' attentiveness, levels of stress, self-discipline and enjoyment of learning [22]. Many studies have shown that open-air classrooms increase well-being and classroom engagement [23,24] while providing a more calm, silent and secure environment for learning [22]. In contrast, a loss of interaction with the environment may hinder the emotional perception associated with health and well-being [25]. Garden-based learning can thus be addressed from an emotional and sensory approach [26]. Sensory perception in a garden provides an opportunity to understand and value the natural environment and to reflect on the role of nature in people's well-being [27]. Additionally, it contributes to the construction of knowledge through the interaction and interpretation of the different elements that are part of the phenotype, such as shapes, sizes, proportions, colours and sounds.

As Escribano [28] pointed out, 87% of human perception is provided by sight; however, the perception by other senses should not be ignored. The research by Sun et al. [29] suggested that auditory and visual perceptions interact. Artistic expression has always been associated with the landscape; however, since at the end of the sixties, composer, music educator and environmentalist Murray Schafer introduced the concept of soundscape, and music has opened up many interesting pedagogical possibilities [30]. For one thing, a soundscape is based on the value of silence and sound by itself as a source of creativity; for another, auditory works encourages observations of the surroundings, as guided and directed listening to the social and natural surroundings provides knowledge not perceived through permanent contact [31]. This sound and visual approach to a garden as an agro-ecological landscape is an opportunity for encouraging aware and active listening to different surroundings and its elements (soil, plants, rest area, insects and pets) and, thus, to look deeper into the relationship between natural sounds and emotions as a basis for promoting environmental awareness [27]. According to Autor2 [32], the moment that a sound has the power to transmit emotion to us, whatever it may be, it becomes sound art. That is the reason why it is so important in educating to create sensory expectations. We can therefore say that soundscapes will become an emotional landscape, and in the words of Carles [33]: "The concept of soundscape allows the sound environment to be represented as a musical composition". In this way the soundscape is formed by the combination of sounds that make up a unique landscape into its own non-transferable sound [34–36].

Within this context, the introduction of ICT, not only as a resource but as a teaching method, can provide many opportunities for developing the interdisciplinary content and professional competences during the initial training of teachers, including digital competences [26]. This is an opportunity to avoid difficulties in accessing a garden due to pandemic restrictions. By implementing a 360-degree virtual simulation using Virtual Reality (VR) and Augmented Reality (AR), garden landscapes can be recreated and, thus, provide a complementary resource to outdoor activities. These techniques enable immersion into previously recorded scenarios, enabling observation, hearing and an understanding of the processes and identification of the environmental problems that are present [26,37]. The learners thus feel themselves to be part of the ecosystem and will reflect on the reasons why problems occur and will search for sensible solutions [38].

VR is a digital simulation of the surroundings in which users can become completely immersed [39]. In VR surroundings, they can move around and see in all directions and interact with objects, providing the pupils with a strong sense of being in the simulated space [40,41]. AR is a digital technique that can complement reality through the recreation of scenarios, surroundings and superimposed images [42]. According to Choat [43], a digital model of the material world can provide a reconceptualisation of the matter in such a way that pupils can learn by experiencing a real world versus a virtual world—for instance, seeing things peripherally through a virtual presence; experiencing the climate, the weather and different surroundings and by virtually touching and examining [44].

Among the reviews on the use of VR and AR, those of Hew and Cheung [45] stand out, which covered research up to 2008, observing their use mainly in the fields of the arts, health and environment. Mikropoulos and Natsis [40] carried out a review from 1999 to 2009 and observed that 40 of the 50 articles revised carried out studies within the context of mathematics and science. The authors concluded that VR's general characteristics involved the principles of constructivism; experiential, contextual and collaborative learning spatial representation and engagement. Kavanaugh et al. [46] carried out a review from 2010 to 2017 focusing on understanding the reasons why VR has not been introduced into education in a more consistent manner and found a series of limitations relating to cost, difficulty of use and even problems of dizziness during the immersion. With the advances made in the systems, VR has taken on many subcategories, such as (a) 3D virtual field trips (VFT) [47,48], (b) 3D virtual worlds [45], (c) 3D virtual learning environment (3D VLE) [39], (d) 3D virtual environment for learning (VEL) [41] and (e) 4D VR [49].

Virtual Field Trips (VFT) can improve accessibility in situations in which it is physically difficult to actually visit an environment due to the climate, the terrain or school resources [48]. Similarly, 3D VFT can introduce the "nature of field work" by involving the learners [47]. Three-dimensional Virtual Field Trips can also familiarise the teachers with field work and encourage them to provide physical trips for their pupils [47,48]. However, Argles et al. [47] argued that, for greater learning, the 3D VFT must be used alongside other tools.

In the last decade, several reports, such as the Horizon report published by NMC (New Media Consortium), have emphasised that AR is one of the emerging technologies with the greatest impact on the world of education due to its potential for modernising educational contexts [50].

The main objective of this research is to evaluate the usefulness of Virtual Reality (VR) and Augmented Reality (AR) as an educational resource through contextualised sensory experiences in the garden in a virtual learning environment.

To attempt to reach this objective, we asked several research questions:

Q1. Is sound and visual perception in a garden-setting similar in both a real and in a virtual environment?

Q2. Is it possible to construct mental models on the landscape of the garden from immersion experiences with AR and VR?

Q3. What is the learners' perception of their learning in immersive virtual surroundings?

Thus, the following specific objectives have been pinpointed:

1. To identify and describe the sound and visual items of the garden during virtual immersion (OBJ1).
2. To compare sensory perception in a physical garden with that of a virtual garden (OBJ2).
3. To analyse the AR compositions created by the participants (OBJ3).
4. To analyse conceptions of a garden from drawings (OBJ4).
5. To evaluate the usefulness of VR and AR as didactic resources in teacher training (OBJ5).

2. Materials and Methods

2.1. Instructional Context and Data Collection

This research used mixed methodology [51]. The mixed methods combine quantitative and qualitative perspectives in the same study, with the aim of providing a depth of analysis when the research questions are complex so that quantitative data are supported by qualitative data for interpretation.

The procedure was carried out in several phases:

- Prior phase. Preparation of the material. Twenty scenes of the garden were chosen in different zones following a path inland from the Mediterranean coast, and 360-degree video recordings were made. The selection of scenes was based on the classification from the Atlas of the agricultural landscapes of Spain [52]. The videos were made by the research group using 360-degree cameras (Samsung VR and GoPro Fusion), along with the corresponding software for editing work (Gear 360 Action Director, GoPro Fusion Studio 1.3 and GoPro VR Player 3.0). These videos were shared on a YouTube channel that the learners could freely access. Table 1 shows the recorded scenes arranged in three categories: coastal garden (9 scenes), inland garden (9 scenes) and school garden (2 scenes). The distinction between coastal garden and inland garden was established in accordance with the following criteria: geographical location, type of crop, climatology and agrarian practices. The coastal garden scenes represent intensive crops characterised by the presence of horticultural crops and intensive irrigation, and the inland garden scenes are characterised by the presence of fruit trees.
- Phase 1. Virtual immersion. Viewing the 360-degree videos took place in the classroom using mobile devices and Virtual Reality (VR) glasses. Each pupil was asked to watch four recordings of their choice. While they were watching, the pupils filled in a qualitative questionnaire ad hoc (AI-1) in which they described the sound and visual items perceived in each of the scenes viewed and responded to a series of open questions.
- Phase 2. Garden design using Augmented Reality. After watching the 360-degree VR scenes, the pupils created different garden compositions from a total of 30 crops available in 3D format. To locate the designed landscapes and relate them to the natural environment, the 3D models were projected with the computer camera over Google Maps images. In this phase, use was made of a collection of 3D models created expressly for this activity with the Aumentaty program (Table 2). The models were arranged in accordance with the type of crop into: horticultural crops (11), fruit trees (8) and other crops (11). This last type included aromatic plants, medicinal plants, ornamental plants and natural plants typical of the ecosystems adjacent to the garden area. A 3D-modelled Augmented Reality workshop was used to explain how the activity worked.
- Phase 3. Draw your ideal garden. Furthermore, the participants were asked to draw a garden with all the items they considered it should contain.
- Phase 4. Reflection. On finishing the experience, a reflection exercise was carried out regarding the didactic potential offered by Virtual Reality and Augmented Reality by implementing two Likert-type questionnaires (AI-2 and AI-3).

Table 1. Collection of 360-degree VR garden scenes: https://bit.ly/3ta1jA4 (accessed on 26 May 22).

Coastal Garden	Inland Garden	School Garden
Walking in garden https://bit.ly/3HozeKo (accessed on 26 May 22).	Almonds https://bit.ly/3K4wNhP (accessed on 26 May 22).	School garden 1 https://bit.ly/3tlIz0J (accessed on 26 May 22).
Among avocados https://bit.ly/3K7gZe3 (accessed on 26 May 22).	Orange trees https://bit.ly/3McUPJu (accessed on 26 May 22).	School gardens 2 https://bit.ly/3IvZIuV (accessed on 26 May 22).
Fruit tree garden https://bit.ly/3MdujiU (accessed on 26 May 22).	Field flora https://bit.ly/3C4JeaO (accessed on 26 May 22).	
Garden soil 2 https://bit.ly/3K0ptnq (accessed on 26 May 22).	Olive trees https://bit.ly/3tatrTu (accessed on 26 May 22).	
Tree soil https://bit.ly/3prEw1s (accessed on 26 May 22).	Bird's eye view https://bit.ly/3C93YhC (accessed 26 May 22).	
Garden dusk https://bit.ly/3voc6cE (accessed on 26 May 22).	Vineyard https://bit.ly/3HvFRuD (accessed on 26 May 22).	
Garden soil 1 https://bit.ly/3Hoz1XC (accessed on 26 May 22).	Daisies https://bit.ly/3thDmXz (accessed on 26 May 22).	
Donkeys https://bit.ly/3vsFbng (accessed on 26 May 22).	Ants https://bit.ly/3C2nFYd (accessed on 26 May 22).	
Garden swing https://bit.ly/3pp9lEi (accessed on 26 May 22).	Life in the soil https://bit.ly/3prFB9w (accessed on 26 May 22).	

Table 2. Three-dimensional models created, arranged by type of vegetation or plant.

Horticultural Crops	Fruit Trees	Other Crops
Artichokes Pumpkin Thistle Onions Cauliflower Tiger nuts Asparagus Strawberries Lettuce Corn Tomato plant	Almond tree Khaki tree Carob tree Fig tree Orange tree Medlar tree Olive tree Vine tree	Fir tree Aloe Vera Cane tree Holm oak tree Ash tree Rush Palm tree Pine tree Rosemary Willow Houseleek tree

A total of 87 students from the 2nd and 3rd years of the Primary Education Teaching Degree Course participated in the study at the Universitat de València in the 2020–2021 academic year. The subjects taken were Natural Sciences for Teachers and Design of Educational Materials, the latter being a specialisation, and Information and Communication Technologies (Table 3).

Table 3. Distribution of participants.

Subject-Matter	Grade	Itineraries	Participants	Total n = 87		
				Female	Male	Average Age
NST	2	Compulsory	36	27	9	21.3
DEM	3	ITC	51	27	24	22.6

NST, Natural sciences for teachers; DEM, Designing educational material; ITC, Information technology communication.

2.2. Instrument and Analysis Tools

The participants completed three questionnaires. The qualitative questionnaire AI-1 was used to identify the garden's sound and visual items and quantitative questionnaires AI-2 and AI-3 for carrying out reflections on the usefulness of VR and AR in teaching. The analysis of the AR compositions and the drawings followed a categorisation process based on a phenomenographic approach [53,54].

The AI-1 questionnaire was made up of 5 open-ended questions:

- P1. Name of the chosen landscape. Explain why you chose this.
- P2. Describe the visual items of the landscape you see.
- P3. Identify the sound items of the landscape and indicate if their origin is natural, human or technological.
- P4. Describe the environmental problems that you see in the landscape.
- P5. What feelings were immersed in the landscape stimulated in you? (describe using adjectives and/or nouns).

The categories obtained in the works of Bones et al. [55] and Autor1 et al. [27] were used to classify the sound and visual by means of a system made up of three categories and seven subcategories—Nature: animals, plants and biotic organisms; Human: voices and music and technological: industrial and home.

These results were subsequently compared with those obtained in real experiences, taking as an example a garden situated in an area nearby the Faculty of Teaching, which was regularly visited before the pandemic and whose results were described by Autor1 et al. [27].

The category system used for the analysis of the drawings and of AR was agreed on after several peer discussions between the researchers. These items were later quantified according to the frequency that they appeared, and the mental models associated with the drawings were identified, taking the mental models identified by Muñoz et al. [56] as a reference for classification.

The data collection tool used for analysis of the participants' perception of the usefulness of VR and AR as a resource for teacher training comprised two 10-point quantitative Likert-type questionnaires (AI-2 and AI-3), where 0 was not at all in agreement and 10 was fully in agreement. Questionnaire AI-2 comprised 8 items on aspects relating to the didactic application of VR and AR for teacher training. Questionnaire AI-3 had 20 items divided into two sections, the first with 12 items for assessing the acquisition of digital competence and the second one with 8 items for assessing the teaching competence acquisition. The second part of the questionnaire was based on general and specific competences taken from the official curriculum of the Primary Education Teaching Degree Course at the University of Valencia.

The relationship between the research questions, the specific objectives and the analysis tools is shown in Table 4.

Table 4. Relationship between the research questions, the specific objectives and the analysis tools.

Research Questions	Objectives	Analysis Tools
Q1	OBJ1, OBJ2	Qualitative questionnaire AI-1
Q2	OBJ3, OBJ4	Categorisation
Q3	OBJ5	Quantitative questionnaires AI-2 and AI-3

3. Results

3.1. VR Virtual Immersion

3.1.1. Selection of Virtual Scenarios

A total of 348 scenarios were analysed, all of which were viewed during the immersion phase. The scenarios chosen, in descending order, correspond to the following categories: coastal garden (44.7%), followed by inland garden (37.2%) and school garden (18.1%). Despite the fact that the school garden was chosen to a lesser degree, it should be taken into account that both the coastal garden and the inland garden contain a greater number of scenes (nine scenes) to choose from than the school garden (two scenes). In a detailed analysis by scenes, avocados, school garden 2 and school garden 1 scenes are the ones with the greatest number of renderings (9.6%, 9.2% and 8.9%, respectively). The learners explained their choices of the scenes of a school garden by referring to the link that the school garden has with their professional future, as they know that many schools have a garden on their premises. In the case of the avocados scene, they explain their choice by the interest that the avocado tree arouses, as it is a tree that the majority are not familiar with, despite the fact they do know the fruit.

At the same time, scenes recorded from the ground (daisies, ants, garden soil and life in the soil) were chosen by a large proportion (7.4–6.4%). They based their explanations for this choice on the unusual perspective provided by the videos, as most observations are filmed at the level of the human eye and that makes it difficult to see details that close to the ground. At the same time, they point out the chance to watch the behaviour of live beings without intervening in the surroundings, as the camera is integrated with the elements in the scene. Lastly, they mention the aesthetics of the landscape as playing an important role in the choice of scenes.

As for the scenes named garden dusk, donkeys and swing, they also show similar percentages in the choices (7.4–6.4%). For the scene named garden dusk, they explain their choice by referring to the aesthetics of the landscape at the time the video recording was made and the positive feelings that it transmits. Regarding the donkeys scene, they mention the interest aroused by the presence of domesticated animals in gardens, and regarding the choice of the swing scenario, they mention memories from childhood.

3.1.2. Description of the Sound and Visual Items

Table 5 shows the results of the analysis of the descriptions of the sound and visual items that the learners noted during the virtual immersion (VR).

Table 5. Sound and visual items noted during the VR immersion.

Category	Subcategory	Sound Items	Visual Items
Nature	Animals	Birds, insect, donkey, bees	Donkey, ants, birds, bees, insects
	Plants	Leaves, branches	Trees, garden vegetables, crops, crops, leaves, flowers, fruit, vegetation, grass, daisies, grapevine, almonds, orange trees, olive trees, avocados, bushes, cane, palm trees, trunks, branches
	Abiotic items	Wind, river	Rocks, stones, mountains, clouds, ground
Human	Voices	Voices, cough, conversation, footsteps, children	Person
	Music	-	-
Technological	Industrial	Cars, helicopter, machine, motor-bike, siren, camera, aeroplane	Road, car park, hoses, tools, cars, streetlights, plastic, sign, large warehouse, mobile phone, factory, spade, watering pipes, hoe
	Home	Swing	Greenhouse, school, plant pots, swing, house, school garden, water tub, chair, fence, door, village, rope, barbecue, firewood

In the virtual immersion, the visual items are noticed more than the sound items, as visual perception is dominant in landscapes [28,29]. This may be due to the fact that many of the visual items do not make sounds. These items may, however, interact and generate different sounds; for instance, the sounds made by the wind in other items. In the case of the Music subcategory, neither any sound nor any visual item was identified.

3.1.3. Environmental Problems

In the majority of the scenes, the participants did not note any environmental problems (38.9%). Regarding the inland gardens, they identified the scarcity of water as the major problem (31.9%) and adventitious flora as an example of poor management of the garden (2.8%). At the same time, noise pollution is mentioned as a health problem as a result of the fact that the noise of cars and other traffic are present in many of the scenes and create an auditory distortion, generating a degree of emotional stress during the immersion (22.2%). Finally, the existence of waste is mentioned (4.2%), pests (2.8%), light pollution caused by the streetlights close to the garden (1.4%) and animal welfare in the case of the donkey as it was held inside an enclosure (1.4%).

3.1.4. Feelings during the Immersion

Most of the feelings described are positive (>95.7%). The term most frequently used is Tranquillity (32.4%), followed by Calm, Relaxation and Peace (12.5%, 11.8% and 11.8%, respectively). Joy and Happiness also show significant percentages (8.8% and 5.9%, respectively). Other feelings that were less mentioned are Disconnection, Satisfaction, Harmony, Liberty and Wellness (≤4.4%).

As for negative feelings (<4.3%), terms such as Sadness and Stress were used. In the case of the term Sadness, it was used for the feeling produced by abandonment of the countryside and the scarcity of animal life in large terrains with hardly any vegetation (inland gardens). Stress, however, is a reference to the presence of acoustic pollution caused by traffic and the movement of motor vehicles in the garden's surroundings.

3.2. Comparison between the Garden's Virtual and Real Sound Perception

The sound and visual elements perceived during the virtual immersion were compared with those perceived in the garden visits conducted before the pandemic. The persons' learning experiences in the garden were conducted during the 2017–2018 and 2018–2019 academic years. Participants completed several questionnaires to record visual and auditory information about the garden and emotional perception and answered questions related to environmental issues. The questionnaires were analysed using the phenomenographic method, and the results were organised into categories: nature, human and technological. The results of these activities situated in the garden are shown in the research of Autor1 et al. [27].

On comparing the number of sound items identified, we found that double sounds were perceived during the virtual immersion similar to during the visit to the garden. The sound items that were best identified virtually were the sounds made by insects and in the different sounds made by vehicles. These sounds during the visits in person were not noticed.

Consequently, with virtual immersion, similar results are obtained to those obtained during in-person visits. In some cases, it is even possible for more items to be identified than in the in-person sessions. That may be due to the fact that, in the case of in-person perceptions, some of the sound items may not be perceived on account of the speed at which they occur, while, in virtual immersion, it is possible to repeat the viewing several times until all the items are identified.

As for emotions, in both cases, pleasant sensations are perceived and are described in the same terms (tranquillity, calm, peace, relaxation, joy and happiness). This indicates to us that virtual reality enables an emotional interaction with the scenario viewed and may constitute an opportunity to become close to reality when it is not possible to physically gain access.

3.3. Compositions of Gardens with Augmented Reality (AR)

Analysis of the compositions created with the 3D models with Augmented Reality (AR) gives the following results (Table 6).

Table 6. Percentage of the presence of crops shown in the AR compositions arranged according to the type of garden.

Type of Crop	Crop	Coastal Garden (n_c = 49) % Presence	Intermediate Zone Garden (n_c = 48) % Presence	Mountain Garden (n_c = 29) % Presence
Horticultural crops	Artichokes	-	6.3	6.9
	Pumpkin	-	10.4	-
	Thistle	-	2.1	3.4
	Onions	6.1	16.7	-
	Cauliflower	6.1	10.4	-
	Tiger nuts	6.1	8.3	-
	Asparagus	-	-	6.9
	Strawberries	-	8.3	-
	Lettuce	6.1	2.1	-
	Corn	8.2	12.5	-
	Tomato plant	-	12.5	-
Fruit trees	Almond tree	-	-	-
	Khaki tree	-	-	-
	Carob tree	-	-	6.9
	Fig tree	-	-	6.9
	Orange tree	-	-	3.4
	Medlar tree	-	-	-
	Olive tree	-	-	-
	Vine tree	-	8.3	-
Other growths	Fir tree	-	-	17.2
	Aloe Vera	12.2	-	-
	Cane tree	4.1	-	-
	Holm oak tree	-	-	13.8
	Ash tree	-	-	10.3
	Rush	10.2	-	-
	Palm tree	22.4	-	-
	Pine tree	6.1	2.1	13.8
	Rosemary	4.1	-	-
	Willow	8.2	-	-
	Houseleek tree	-	-	10.3

n_c = number of crops represented in each type of garden.

The compositions of the gardens situated in the coastal and intermediate zones contain a greater number of crops than do those of mountain gardens. Additionally, in intermediate zone gardens, there is a greater percentage of horticultural crops (89.6%) than in the coastal zone (32.6%) and mountain zone (17.2%). This may be due to the pupils acknowledging that, in the areas close to the coast, with a mild climate, there is a greater diversity of crops than in the inland zone with its cooler climate.

At the same time, in the coastal zone, there is a predominance of crops resistant to salinity and adapted to sandy soils (aloe, cane, palm trees willows and so on). In the mountain gardens, the cultivation of fruit trees and arboreal species typical of mountain ecosystems stands out (pine trees, fir trees, ash trees and holm oak trees).

Nevertheless, crops appear that do not correspond to the zone in which they have been seen, such as, for instance, the vine tree that would correspond to the most inland zone (mountain garden). The absence of almond and olive trees stands out in the compositions, despite the fact they are very common fruit trees in inland gardens.

3.4. Analysis of Drawings and Determination of Mental Models

Firstly, an effort was made to verify the absence or presence of items contained in the drawings, and they were arranged into three components: natural, technological and sociological. For each of the components, the items were arranged by category, and the frequency of their presence was quantified (Table 7)

Table 7. Frequency of appearance of relevant items in the drawings.

Component	Category	Item	Presence Frequency (%)
Natural	Flora	Trees	21.9
		Horticultural products	21.9
		Flowers and aromatic plants	4.8
	Fauna	Insects	2.9
		Domesticated animals	3.8
		Birds	3.8
	Abiotic	Mountain	4.8
		Water	2.9
		Sun, clouds	6.7
Technological	Vehicles	Tractor, bicycle, car	0.1
	Thoroughfares	Paths, roads, bridges	0.2
Sociological	Leisure	Deckchair, rest area	2.9
	Constructions	Shed, house, fence, greenhouse	18.1
	Tools	Wheelbarrow, hoe	1.9
	People	Children, adults	1.9

From the whole of the items shown in the drawings, 43.8% are crops from fruit trees and horticultural crops divided in equal proportions. In the second place, they show constructions associated with the garden (shed, fence and greenhouse) and the living quarters that are integrated into the space in such a way that all the items are related to one another. The abiotic items (mountain, water, sun and clouds) show an aspect of the garden that is close to that of the natural landscape, which they relate to the nearby ecosystems.

Four mental models of the garden have been identified, taking as a reference the studies of Muñoz et al. [55] and defining some descriptors to classify them. The models identified are as follows: landscape, bucolic-pastoral, architectonic and productive. The bucolic-pastoral model is the one shown most in the drawings (41.9%) and shows a predominance of the natural elements (flora, fauna and abiotic) over the rest of the components. In this model, the human presence is integrated into the landscape in a respectful way through sustainable activities. These drawings are associated with rural surroundings. A predominance of horticultural and fruit crops can be seen, with some construction items (shed, house and bridge), that show the use of the garden and the integration of the sociological items in a manner that is respectful with the surroundings. In the landscape model (22.6%), the abiotic items, such as the mountains, rivers and the sun, and the presence of flowers and insects show a garden scene that is closer to nature. They are gardens with a high degree of conservation and integration into the landscape and where a human presence is merely of residues or non-existent. At the same time, the architectonic model (22.6%) shows the layout of the crops in check-shaped plots and a well-defined geometric pattern with the items arranged as if they were a plan. Finally, the productive model (12.9%) shows items that are strongly linked to production, such as greenhouses, farm tools and vehicles for transporting the production.

3.5. Usefulness of VR and AR as a Tool for Learning and for Teacher Training

Table 8 gives the average scores obtained in the indicators of usefulness, showing that, for all the points, the scores are more than 7.5. The results indicate that AR and VR are, at the same time, instruments, resources and contents, which strengthens the idea that they can favour the development of competence in future ICT teachers. At the same time, it highlights the role of these technologies in developing and improving the understanding of concrete contents and, thus, encourages reflection.

Table 8. Didactic usefulness of augmented and virtual reality.

Usefulness Indicators	Value
AR and VR are a tool, a didactic resource and a learning content	8.8
They are useful for clarifying content, for thinking and meditating	7.9
They encourage discussion and debate	7.5
They increase information relating to a specific subject	8.3
They encourage observation, analysis and reflection	7.5
The tutorials and video tutorials have made learning and the use of virtual and augmented reality resources easier for me	7.5
They increase the capacity to adapt to new training and learning formats, both in the role of user and in that of designer of learning environments	7.7
Educational use of ICT improves competences in communication and social interaction	7.5

Here we highlight some of the thoughts expressed by the pupils during the activity that show the pedagogic potential of AR and VR:

- Showing difficult-to-access places and situations:
  - "It's useful for showing the class things that you cannot normally show, like faraway countries, special places, observing wild animals".
  - "We can use the following videos to work on different surroundings and even the world's climates and our country's too. As well, we can use them to work on what these countries and their climates are like, with the animals, fauna and flora in those countries and climates . . . "
  - "Mainly to bring them close up to different places that they have never been to, and then show them different content, for example, show them a landscape and then speak about its trees, and animals . . . "
- Interdisciplinarity and holistic focus on knowledge:
  - "For ages at Primary School it's very useful to use them because you can study the rural world (fruit and vegetables), the human body, the planets, geography, etc. You can use them for many things in different areas and competences in the curriculum."
  - "This resource's educational potential is very far-reaching. You can work on lots of content and bring faraway places and aspects of the natural environment into the classroom".
- Clarification of content:
  - "With the VR glasses the learners can see landscapes that they perhaps would never see in the real world. What's more, they can see them very clearly and close up because the impression with the glasses and sounds make the images appear real".
  - "It can be a tool for motivating as it is something new and attractive and can incentivise learners to engage and pay attention to the explanations on some subject."

The results of the pupils' perceptions on the development of digital and teaching competences are shown in Tables 9 and 10. In Table 9, it can be seen that, in all the indicators analysed, the learners' perceptions regarding the acquisition of competences were high, particularly those relating to the management of technological resources and education training in the use of ICT. On the other hand, some difficulties were found regarding the use of audio visual and hypermedia language.

As for teaching competences (Table 10), it is notable that the learners' positive perceptions regarding true reality as a relevant aspect of teacher training, the promotion of cooperative work and the approach to nature as a basis for potentiating respectful and committed attitudes towards the environment.

Table 9. Learners' perceptions regarding the acquisition of digital competences.

Indicators on Acquisition of Digital Competences	Value
They have helped me to increase my basic knowledge of IT systems, networks and the management of IT equipment.	8.1
They have helped me to improve the design and editing of digital images: scanner, camera, digital video and screen shots.	7.2
They have helped me to improve my knowledge of and how to use hypermedia and audio visual languages.	7.0
They have helped me to improve my management of technological systems applied to education: conventional audio visuals, 360 degree editing programs, mobile apps and so on.	8.7
I have applied new didactic, creative and innovative strategies that make use of ICT resources both in the classroom and in informal educational spaces (virtual itineraries through the natural and the human environment).	7.5
The activities performed have enabled me to select and objectively evaluate ICT platform educational resources.	7.6
In teacher training it is important to constantly renew and update knowledge through the pedagogical and research-based use of ICT.	8.9
Educational use of ICT improves the capacity to produce, communicate and disseminate research processes by means of technological tools and platforms.	8.3
I have improved my competence in designing, evaluating and making use of notes and multimedia teaching material from a comprehensive, holistic and integrative points of view.	7.8
I have improved my competence in selecting, organising, publishing and sharing my own work through the Internet.	7.9
I have improved in searching for high quality images, audios and videos bearing in mind author's rights and restrictions on their use (copyright, Creative Commons).	7.9
I have improved my digital teaching competences.	8.2

Table 10. Learners' perceptions on the acquisition of teaching competences.

General Competences (GS) and Specific Competences (SS) (Official Curriculum in Degree Course for Teaching Primary Education—University of Valencia	Value
GS4. Critically analysing and incorporating the issues most relevant in present-day society affecting both family and school education.	8.0
GS5. Encouraging cooperative and individual work.	9.0
GS6. Accepting that the exercise of pedagogical activities has to continue being perfected and adapting to scientific, didactic and social changes throughout one's life.	8.7
GS9. Designing, planning and evaluating teaching activity and learning.	8.7
GS12. Understanding that systematic observation is a basic tool for enabling one to reflect on practice and on reality and also contributes to innovation and improvement in education.	7.9
SS124. Proposing activities focusing on solving daily life problems using scientific language and applying scientific reasoning.	8.5
CE127. Encouraging interest and respect for the environment and health through didactic projects.	9.5
Degree of acquisition of professional teaching competences	8.6

4. Discussion

The aim of this study was to evaluate the usefulness of Virtual Reality and Augmented Reality as a resource in education that enables learners to be close to the natural environment by means of immersive experiences. This provides the opportunity to use a virtual learning environment to establish relationships between theoretical and practical contents and thus increase the understanding of complex processes (soil–plant relationships and interactions between visual and sound items) through quasi-real experiences.

Through this virtual experience, the pupils can revise concepts on the sound and visual items in the garden (biotic, abiotic, natural and technological) in a similar way to the studies of Lin et al. [57]. During immersion, the learners explore the simulations and answer questions relating to the scenarios visited. This immersion was carried out in an asynchronous manner, which allows control over the viewing and allows repetition of the experience as many times as necessary. This is very significant, as the pupils can meticulously observe all the visual and sound items of the gardens they view without missing any of the situations in the landscape.

At the same time, exploring the sound and visual items in the gardens and analysing the environmental impacts by means of a constructivist learning approach based on enquiry (EBL) requires that the learners approach real-world problems by collecting and interpreting data and that they reflect on evidence to reach conclusions, develop curiosity and ask more questions related to specific learning objectives, as pointed out in the studies of Minocha et al. [58] and Pederson and Irby [41].

These future teachers' works with a virtual garden can generate learning and even emotions. Thus, they acknowledge, in a similar fashion to being actually present, the garden's potential for promoting values and attitudes and for working on Environmental Education, as shown in the works of Aragón and Cruz [59], Ceballos et al. [1], Eugenio and Aragón [7] and Eugenio et al. [19], among others.

In this virtual learning environment, the pupils form a personal and subjective model of reality and can construct new ideas from experimentation, where experiment and experience are essential [47,60]. In addition, the 3D models and VR immersion offer many perspectives on the spatial distribution of items in the landscape similar to that perceived in the physical environment.

The landscape should form part of the education process, as, in so far as those two components, emotion and rigour, interact, creativity in the scientific field grows [61]. In this regard, it is important to know the mental models that the immersion experiences induce in future teachers as the link between landscape, the social sciences and the natural environment is undeniable. This research into the use of virtual and augmented reality has made it possible to dig deeper into the educational potential of virtual learning environments and of looking closely at a sound and visual garden as a basis for reflection and the acquisition of both digital competence and teaching competence.

We believe that more research is needed on gardens as teaching and learning contexts [17,62,63]. This research that we have submitted has the limitation that it uses a rather small sample and that it had to make use of the results of previous terms' courses so that comparisons with in-person visits could be made. The conditions caused by the lockdown restrictions have helped in the making of this virtual look at sound and visual garden with AR and AR, which we consider to be the main innovative contribution of the work, as there are few previous instances of research on garden in non-physical contexts [64].

As regards the limitations of AR technology, the lack of training in its use is notable, and it requires an effort on the part of the experts to improve their ease-of-use of the apps, battery consumption and the multifunctionality [65].

Additionally, we can highlight some difficulties noted during the experience: (i) Problems with vision (learners with spectacles may have problems seeing virtual reality) and compatibility with the devices (not all mobile devices are compatible with the app required for watching the videos in virtual reality). (ii) Limitations due to the amount of resources required, such as computer equipment, VR goggles, etc. Some schools have difficulty in affording the technologies, which limits their inclusion in the curriculum. (iii) It can also be a problem working with a large group, and more teachers/assistants may be required in order to put into effect an ideal educational experience. (iv) Focusing the eyes can lead to a little dizziness [46]. This could be avoided by improving the quality of the glasses, although, to do that, more technological development at the user level needs to be done. (v) The difficulty in handling the items of the landscape represented. We are limited to just what we see and hear, and it is not possible to interact with the other senses, and so the information perceived is only partial.

In summary, it should be borne in mind that the steps from face-to-face teaching to teaching online must be carefully planned by using a systematic model for their design and development [66], as a rapid switch from the in-person model to an online model may affect their learning efficacy [67]. Academic research suggests that AR/VR is an effective resource in education and totally compatible with the current push for digital/hybrid learning [68]. Thus, the creation of virtual spaces contextualised in the sound and visual perception of a garden constitute a valuable educational resource for the interdisciplinary training of future teachers.

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