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Evaluating a holographic mobile-based application for teaching basic oral English vocabulary to Spanish speaking children

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Abstract

This paper describes the development, use, and evaluation of a holographic mobile-based application for teaching basic English as a second language, in particular, oral vocabulary to Spanish speaking children. The mastery of vocabulary is a fundamental step when learning a language but is often perceived as boring. And to speak the correct pronunciation is frequently regarded as the most difficult and complex skill for new learners of English. In order to address this problem this research takes advantage of the power of multi-channel stimuli (sound, image and interaction) of a mobile-based hologram application in order to motivate students and improve their learning experience. We adapted the prize-winning HolograFX game and developed a new mobile application to help practice English pronunciation. A 3D holographic robot that acts as a virtual teacher is in charge of teaching oral English vocabulary. To test the tool we carried out an experiment with 70 Spanish pre-school children divided into three classes, the control group using traditional teaching, and two experimental groups using drills and practice software. One experimental group used the mobile application without the holographic game and the other experimental group used the application with the holographic game. We performed pre-test and post-test performance assessments, a satisfaction survey and emotion analysis. The results are very promising. They show that the use of the holographic mobile-based application had a significant impact on the children's motivation. It also improved their performance compared to traditional methods used in the classroom such as using images in books and on the blackboard.

Keywords: Holograms, Mobile Applications, Interactive Learning Environments, English Foreign Language, Learning at Early Age.

1.Introduction

Learning a foreign language such as English centers on four basic skills: listening, reading, speaking and basic writing skills (Peregoy and Boilly, 2001). Normally, all of these skills are taught as a whole, but vocabulary learning is very important and is a prerequisite for language learning (Agca & Ozdemir, 2013). In fact, one of the components of mastering English as a Foreign Language (EFL) is vocabulary mastery (Nation, 2013), which means students being capable of understanding and using the words (Zahedi & Abdi, 2012). Vocabulary, as Brown (2001) states, forms the building blocks of any language. Due to its importance, vocabulary acquisition is receiving much more attention in Second Language (L2) pedagogy and research. Vocabulary can be classified as oral or written. Teaching and learning new vocabulary has traditionally focused primarily on definitions, but pronunciation is clearly an important factor in learning new words (Sweeting, 2016). Teachers should facilitate this learning by not only explaining definitions but also modeling the pronunciation of these words. The importance of beginning to train a child's pronunciation skills in a L2 at an early age has long been known to researchers and educators (Neri et al. 2008). It is much easier to introduce sound systems to children when children are usually simply copying what they hear, and building up mental generalizations based on their experiences (McMahon, 2002). Therefore, researchers and educators must devise optimal ways to provide pronunciation training for young learners. A good example is the new concept of using of speech recognition technology in teaching language pronunciation to new learners (Liaw, 2014); it can be seen in the literature that this is a burgeoning field of research (Cavus, 2016).

Vocabulary acquisition is hard and requires more effort and time in a L2 than a L1 (Suwantarathip and Orawiwatnakul, 2015). In addition, many EFL learners find vocabulary learning boring, as they have to repeat and memorize unfamiliar words and spelling (Nguyen and Khuat, 2003). It is imperative for teachers to find ways to help students learn English vocabulary in more motivating and interactive ways (Liu, 2014). Adult students are always interested in learning EFL at first. However, they lose their interest in learning gradually due to the difficulties they face when reading, communicating, and listening (Alkhalifah et al., 2012). Obviously, there are differences in teaching EFL to children compared to teaching adults or adolescents. Children are often more enthusiastic and lively as learners, but they also lose interest more quickly, they are less able to keep themselves motivated in tasks that they find difficult, and they do not have the same access as older learners to the metalanguage that teachers use to explain (Cameron, 2001). Teaching a foreign language in infant education is a challenge (Flores and Corcoll, 2015) and English teachers who teach young children need to understand what it is like to be a child in order to be aware of the obstacles and difficulties that may be encountered in the process, and be ready for the challenge. Children have a natural instinct for play and fun, they demand a great deal of creativity and energy during interaction; if they are bored they won't pay attention, and they won't learn (Simona, 2015). Therefore, teachers of early-age learners have an important role to play in guiding children to English in a motivating way (Cameron, 2001). Computer-Assisted Language Learning (CALL) systems use multimedia and games in order to engage learners (Yip and Kwan, 2006). Previous researches indicate that technology may increase students' motivation, especially in the case of children, and help them overcome previous difficulties (Alkhalifah et al., 2012) (Finnsson, 2015) (Wu, 2013). Teachers have the dual task of motivating and teaching, and one way of carrying out that task may be by taking advantage of the huge potential of modern-day students´ digital literacy to introduce technological innovations and computer games that enrich and encourage early-age learners to participate in educational activities in the classroom (Martins et al., 2015). Several studies suggest that computer applications and games appear to have a positive impact on EFL learning in school and pre-school (Finnsson, 2015) and are a key way to increase children's interest (Wu, 2013).

In this research we propose the use of a novel type of computer game created with hologram technology, which is one of the most creative areas in the field of Information Communication Technology (ICT) usage in learning environments (Ghuloum, 2010). The potential of audiovisual materials is already well known as they present a combination of sound, images and creative elements for learners to interact with (Squire, 2002). Holograms have broad potential applications in education. For example, students and teachers may be able to communicate and interact from distant locations, students might benefit from realistic and convincing visuals of study materials, a holographic teacher might appear to be in the classroom and be able to see and speak to the students as if they were all in the same room, which may enable interesting and efficient interactions between students and teachers (Kalansooriya et al., 2015). In addition, holograms could enhance the educational process by bringing famous or fictional characters to life, so to speak, to talk about themselves or even add something as an assistant teacher, which could be interesting, motivating, and without doubt, an innovation in the teaching-learning process. With this objective in mind, we describe how we adapted a holographic game to be used for educational purposes. We also developed a specific Android mobile application (app) for teaching basic oral English vocabulary to Spanish children. The app can also be used in a smartphone without the holographic game, in which case the image will be seen on screen rather than using holograms. We chose to teach the learning and pronunciation of basic vocabulary as the content because it is one of the first and most frequent skills when teaching English to children (Wu, 2013), and because it is in the official Spanish academic curricula for EFL at early-ages. We used a funny 3D holographic robot that acts as the virtual teacher in charge of teaching basic English. Children interact directly with the holographic robot through speech and see the corresponding term as 3D holograms. These 3D images help children learn words with their pronunciation. Our idea is that they associate the 3D image they see with the sounds they hear. Our idea is that a real teacher can use the holographic mobile-based application as an additional resource in the classroom to motivate children in a funny way. Following on from that, our research objective is to test the following hypotheses:

- **H1:** Children perform better when learning and practicing basic oral English vocabulary using a mobile-based application with or without a holographic game than using the traditional methods used in the classroom (images in books and on the board).

- **H2:** Children demonstrate a preference for using a mobile-based application with or without a holographic game for learning and practicing oral English vocabulary rather than the traditional methods used in the classroom.

The paper is arranged as follows. Firstly, the related background is described. Next, the adaptation of the holographic game is presented together with the Android holographic application, followed by the experimental results. The results are then discussed, including conclusions and lines for future research.

2.Background

There are a wide range of methods for facilitating the acquisition of L2 vocabulary ranging from traditional instruction, dictionaries and pictures, to mobile applications and games (Chiu, 2013) (Nation, 2013). There are three categories of traditional techniques of teaching vocabulary (Gairns and Redman, 1986):

- Visual techniques. These techniques concern visual memory. They consist of flashcards, photographs, pictures, blackboard drawings, wall charts, mimes and gestures. They are used in expressing words' meanings. These techniques are especially helpful in introducing certain parts of vocabulary such as: real objects, places, professions, descriptions of people, action and activities.

- Verbal techniques. These include word lists, dictionary use, illustrative situations, synonyms and definitions, contrasts and opposites, scales and examples. These are the very useful for illustrating abstract words.

- Translation. This is considered as an effective way to convey meaning. It helps to save time, especially in cases of teaching low frequency words. However, it is unproductive when teachers overuse translation.

Mobile learning (m-learning) refers to the use of mobile technologies for educational purposes. These devices can offer multiple learning opportunities which may be spontaneous, informal, contextual, portable, ubiquitous, pervasive, and personal (Kukulska-Hulme et al, 2011). There is a hundreds of Mobile-Assisted Language Learning (MALL) publications over the past twenty years that use SMS/MMS, PDAs and smartphones (Burston, 2015). And nowadays, there are an increasing number of mobile apps (software application) for EFL purposes available on the market at present (Pilar et al. 2013). The apps can be categorized into several groups according to their contents: a) games, very often targeted towards children; b) app versions of dictionaries, handbooks and textbooks; c) apps providing vocabulary, grammar and/or pronunciation practice; d) the adaptation of online courses to mobile devices; and e) apps that provide the use of language in context, presented in a variety of ways such as podcasts, videos, films and cartoons. During recent years, mobile learning has been increasingly used to facilitate language learning in all skills, however, it is vocabulary which is the most often targeted skill with this type of technology (Suwantarathip and Orawiwatnakul, 2015). Mobile learning environments encourage students‘ curiosity and make the vocabulary learning activity more attractive and motivational (Agca and Ozdemir, 2013). There are a variety of specific mobile interactive English pronunciation applications for improving EFL students‘ pronunciation skills (Agusalim et al. 2014). Some of these mobile applications use a speech recognition engine (Cavus, 2016). This type of engine can recognize spoken words so that pronunciation errors can be easily identified and corrected. Similarly, speech recognition technology has also been used to support a group of elementary school children's learning of EFL (Liaw, 2014).

Games are an ideal mechanism for designing educational activities with children (Nacher et al. 2015). Different categories of games are used as educational tools (Freitas, 2006; StojkoviĤ and JerotijeviĤ, 2011) such as educational games, online games, serious games, simulations, structure games, vocabulary games and number games. Computer games have become a popular strategy for learning and there are an increasing number of examples of computer games developed specifically for young children and kindergarteners (Vangnes et al, 2012). Playing computer games has been found to be linked to a range of perceptual, cognitive, behavioral, affective, and motivational impacts and outcomes. Evidence of their effectiveness can be seen in existing results and data (Tobias, Fletcher, & Wind, 2014). Game based learning describes an approach to teaching, where students explore relevant aspects of games in a learning context designed by teachers or researchers. Game playing is a good way to engage learners in language learning for a number of reasons (Prensky, 2001): games motivate players (to achieve goals), they gratify the ego (when winning), they are fun (through enjoyment and pleasure), and they spark the players' creativity (to solve the game). Games can focus on various skills, grammar, listening, speaking, writing, reading, and pronunciation, (Simona, 2015).

Magic show games are a specific type of game that have been successfully used in education. Since children and adults are fascinated by magic tricks, this strategy for learning can be effective and memorable (Carrasquillo, 2013). Magic is one of the oldest performing arts in the world in which audiences are entertained by staged tricks, effects or illusions of seemingly impossible or supernatural feats using natural means (Dunninger, 1987). Magic has been used to inspire children about science and technology for centuries (Curzon and McOwan, 2008). It is standard a fare for Chemistry teachers to use 'magical potions' to engage children with chemistry. Similarly, Mathematics teachers use simple number based tricks to inspire wonder in mathematics. The use of magic tricks with children to assist in the development of cognitive, motor, speech, and psychosocial skills in a therapeutic rehabilitation setting is well established (Spencer, 2012). Magic tricks have been used to enthuse children and to introduce formal methodological concepts and computer science (Curzon and McOwan, 2013). Along similar lines, origami (paper folding) and magic tricks have been proposed as tools to teach English (Vichea, 2010), they have been adapted for separate macro skills (i.e. listening, speaking, reading and writing) or integrated skills which promote communicative language teaching and learning.

In this research we adapted a Holographic magic show game for teaching English vocabulary. A hologram is a 3D photographic image that appears to have depth. It can be defined as a three-dimensional record of the positive interference of laser light waves (Vincent, 2012). Holography began in the 1940s, when Dennis Gabor invented the hologram and won the Nobel Prize for the achievement (Gabor, 1948). Significant advances occurred when 3D Holographic Technology (3DHT) was created in 1962 by scientists in both the United States of America and the Soviet Union (Ghuloum, 2010). 3DHT operates by creating the illusion of three-dimensional imagery. Society has come to accept the idea of 3D images or holograms as being a part of our lives due to movies such as Star Wars and Star Trek (Sharton, 2010). Hence 3D Holograms have broken out of the world of science fiction and fantasy and are also being used in advertising, entertainment, social networking, and more. However, as is the case with much technology, there are some barriers and disadvantages to 3DHT, for example, the high cost of infrastructure, the need for a screening room with compatible lighting, and the lack of technical expertise. A way to avoid most of these problems is to use the illusion known as Pepper’s Ghost (Steinmeyer, 2013). This technique, used in theatre, haunted houses, and magic tricks, uses a large piece of glass or plastic film placed at an angle between the viewer and the scene. The glass or plastic reflects a room hidden from the viewer that is a mirror-image of the scene. Pepper's Ghost achieves a better effect by using a dark background with a single reflection. In this research we use the Pepper’s Ghost technique to create an affordable, accessible simulated holographic projection using a smartphone.

Holograms have already been used successfully in adult learning environments, especially in medicine. Medical Holography for Basic Anatomy Training allows the learner to view full parallax, auto-stereoscopic 3D human anatomy images (Hackett, 2013). Holograms of human organs have also been used to teach medical students simple dissections and health protocols as well as the latest surgical techniques (Ko, 1998). Holograms uniquely facilitate the spontaneous understanding of human neuroanatomical relationship which cannot be easily learned using photographs or diagrams (Ko and Webster, 1995). In other applications holography provides better visual aids than either photographs or line drawings in training, and for working aids in application such as construction, technical documentation, and storage (Frey and Eichert, 1978). Holograms provide also better perception of the 3D model shapes for mechanical engineering parts before and during the process of learning how to draw them (Figueiredo et al., 2014). Holograms can also be used as teaching aids designed to prompt viewers (Walker, 2012). Life-size holographic images that speak and answer questions can be used as educational and training aids for different specializations (Leuski et al., 2006). Holograms can enhance the educational process by bringing famous characters from the past back to life, to speak about themselves or explain something as an assistant teacher (Ghuloum, 2010). Finally, it is important to note that, to our knowledge, holograms have not yet been used in an educational environment with early age children as we propose here, nor have we found any magic show games that use holograms for teaching English to children.

3.Adapting a Holographic Game and developing a mobile-based application

In order to create simulated holograms, we used a holographic game called HolograFX (http://holografxgame.com/) that allows users to perform magic shows using holograms on their smartphones. The game`s authors Mark Setteducati and Andre Armenante use the technology behind the classic Pepper's Ghost magic trick (Settembre, 2013). HolograFX was chosen as the 2013 Top Tech Toy at Toy Fair by the organizers of Gadget Show Live, the leading consumer tech event in the United Kingdom (http://www.toynews-online.biz/news/read/toy-fair-daily-gadget-show-names-holografx-as-best-tech-toy/031482). HolograFX (see Figure 1) uses a stage with a transparent reflective plastic screen in the middle and on one side a Smartphone holder for hiding the mobile. Users perform the actions and tricks by using accessories on the opposite side of the smartphone which projects a hologram on the screen to support the show. HolograFX doesn’t include a smartphone with the game components so one is required on which the specific HolograFX app can be installed. This app is not aimed at education and contains prerecorded videos, which combine tricks with holograms such as teleportation, and objects appearing and disappearing.

Figure 1: HolograFX game.

In order to adapt the game to teach basic English to children through 3DHT, we developed a completely new Android app (a demo is free to download from Google Play for Education https://play.google.com/store/apps/details?id=com.XXXXXX.hi2). This app is aimed at learning basic English vocabulary such as animals, plants, vehicles, clothes, etc. Although our app uses a similar interface to the original HolograFX app, it is a new application with completely different functionality (see Figure 2). The first image in Figure 2 shows the main menu, with options to learn, practice or evaluate English vocabulary. We used a 3D robot, called *Arturito*, as the virtual teacher (see the 2nd image in Figure 2), and animated 3D images that represent the terms to learn (see the 3rd image in Figure 2) as holograms. For each word-to-learn our app has a black background video file with an animation of the corresponding 3D object and a sound file with its correct English pronunciation. Finally, we also developed a scoreboard to give a teacher the childrens‘ answers (see the 4th image in Figure 2).

Figure 2: Screenshots of the Android holographic mobile-based application for teaching basic English vocabulary.

Our app has 4 main options or function modes (see the first image of Figure 2):

- **Learn (*Aprende*)** mode**.** *Arturito* introduces each term in Spanish (see image three in Figure 2), then repeats each term in English.
- **Practice: sequential mode (*Practica: modo secuencial*).** In Spanish, *Arturito* asks a student how to say each term in English in sequential order, and waits for a reply. For each attempt, he says whether the student's answer is correct or incorrect.
- **Practice: adaptive/random mode (*Practica: modo adaptativo/aleatorio*).** In Spanish, *Arturito* asks a student how to say the term in English, in this mode the questions do not follow the sequential order, but rather are presented in a random or adaptive order. In this work we have only used the random order. For each attempt, he says whether the student's answer is correct or incorrect.
- **Evaluate (*Evalua*) mode.** In Spanish, *Arturito* asks a student how to say the term in English. He does not tell each student whether their answer is correct or incorrect. Finally, a scoreboard (see the last image in Figure 2) is displayed with the children's results for each word: Correct (Correcto) or Incorrect (Error).

In order to increase children's motivation to practice we added an animation of *Arturito* dancing and singing at the end of each mode. Our goal was to keep children engaged and excited to complete each mode and to do the tasks that would allow them to see what Arturito would do at the end by presenting a funny game-based learning environment for encouraging the children to work toward a goal without worrying to make a mistake.

It is important to note that all interaction between *Arturito* (hologram) and the students is via sound and voice (see Figure 3). We used the Android Speech API to access the speech recognition service (https://developer.android.com/reference/android/speech/SpeechRecognizer.html). Children listen to Arturito to speak the pronunciation of the vocabulary words. The correct pronunciation of each of the vocabulary words was stored as a voice file beforehand. These files were recorded by a native English speaker and a robot filter was applied to the audio to make it more realistically robot-like. When a student speaks or replies to Arturito, their audio is automatically translated into text and compared to the corresponding vocabulary words in order to check if it is correct or incorrect.

Students do not look at the screen of the smartphone; they see the hologram that appears on the far side of the transparent plastic (see Figure 3). So they believe that they talk directly to *Arturito*. In fact, they do not notice that they really interact via voice and sound with the hidden Smartphone that is on the side of the stage closest to them. Our app can be also used without the HolograFX game. In this case, the teacher or student himself must hold the smartphone in their hand and look at the screen. The interaction is via voice and sound but students see that they interact with a smartphone. Arturito and the 3D images appear directly on the screen of the smartphone instead of as holograms.

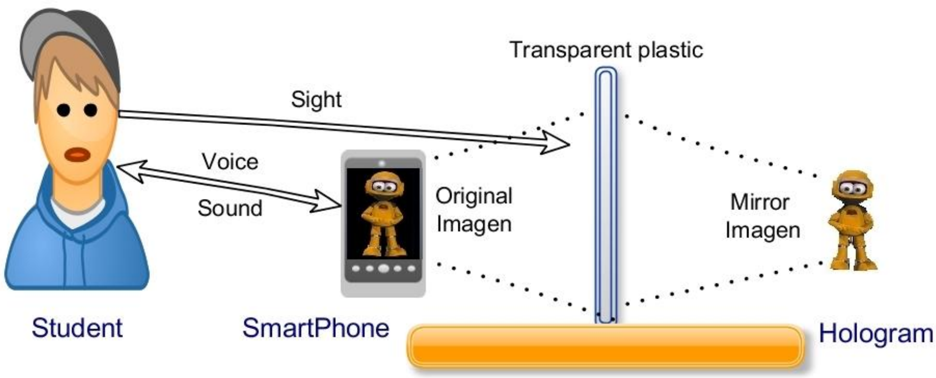

Figure 3: Student-Hologram interaction.

We also made some modifications to the physical structure of the original HolograFX game (see Figure 4) in order to improve it for use in a classroom setting with children. In particular, we added:

- A large black box to cover the hologam side of the stage to improve the visibility of the hologram in a room with daylight.
- A picture of a traditional microphone at the back of the box where we hide the Smartphone so that children know that they have to speak near to this location.
- A miniature wooden desk/table as an accessory to simulate a traditional teacher‘s desk above which the holograms will appear.

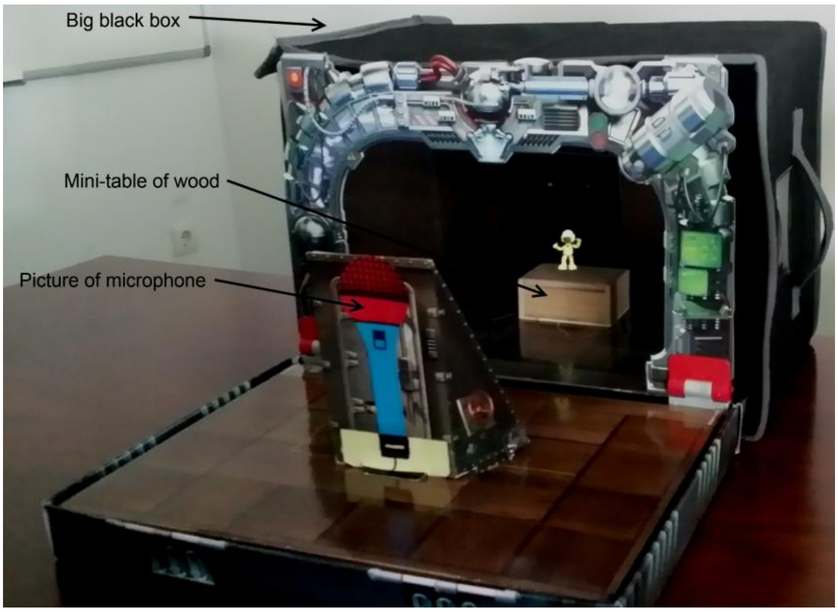

Figure 4: Modifications in the structure of the holographic game.

We also tried to maintain the original magical feeling of the HolograFX game which allows the performance magic tricks by the interaction of accessories with the hologram. To that end, we used the miniature desk, into which we placed small cards (see Figure 5) with pictures of both *Arturito* and the vocabulary items. We show the children how we put the small cards into the mini desk so that they know that they are there and they believe that they become real from inside the mini-desk.

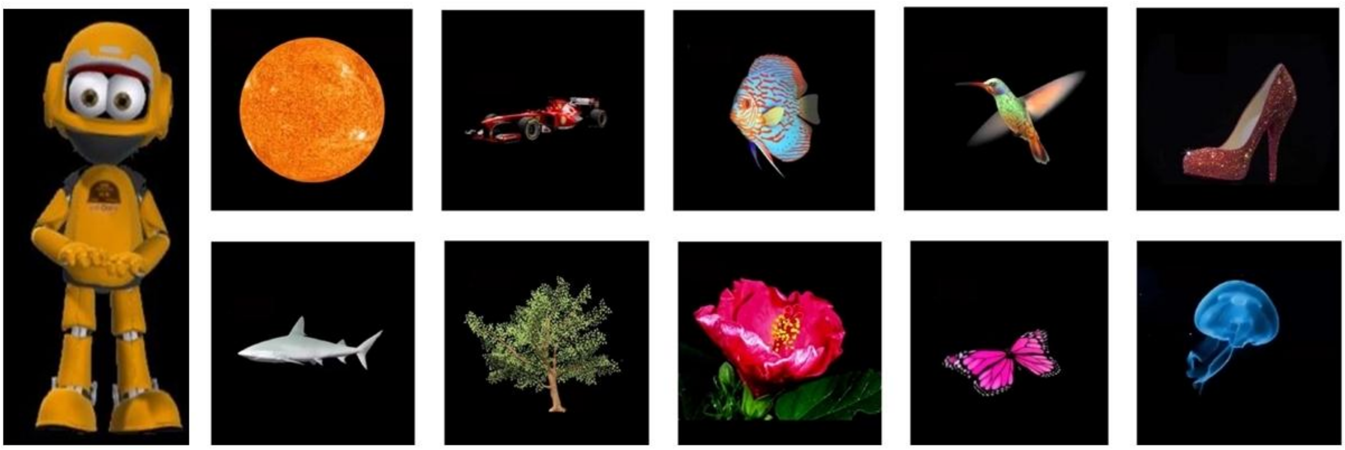

Figure 5: Examples of small cards used as accessories to put into the mini wooden table.

4.Method

We performed an experiment with 70 pre-school Spanish children divided into three classes. The first class was the control group using traditional teaching, the other two were experimental groups using the training software. One experimental group used the mobile application without the 3DHT and the other experimental group used the application with the 3DHT. In both cases the application used the same types of interactions but either with or without the hologram element of the game. We randomly assigned each class to a different group, following a pre-test, and finally the children were given a final satisfaction survey and an image was captured for emotional analysis.

4.1. Participants

Our participants were 70 pre-school Spanish children from a public school in Castilla La Mancha (Spain) divided into three classes with a similar level of performance in English language classes. The children were 4 or 5 years old and in their second year of pre-school. The experiment was performed during the third trimester of the foreign language class in the academic year 2015-2016. The objective was to revise basic oral English vocabulary using different methodologies/techniques.

The same teacher taught the three classes. Although the study had not recruited students on a random basis but instead used existing classes, teachers randomly divided each class into four subgroups of about 6 children, each class was randomly labeled a control or experimental group as follows:

- Control Group (CG): Class 1 with 24 children (13 boys and 11 girls) divided into four subgroups of 6 children each. They used traditional images in books and on the board.
- Experimental Group 1 (EG1): Class 2 with 23 children (10 boys and 13 girls) divided into four subgroups (three subgroups of 6 and one of 5). They used the app without the holographic game.
- Experimental Group 2 (EG2): Class 3 with 23 children (12 boys and 11 girls) divided into four subgroups (three subgroups of 6 and one of 5). They used the app with the holographic game.

4.2 Procedure

The experiment is about learning and practicing pronunciation of English words. The vocabulary is made up of 20 words of differing lengths. A selection of one-, two-, and three-syllable concrete nouns from different domains (animals, plants, vehicles, clothes and space) was included (see Table 1). Two different versions of this vocabulary was used. The two versions contain pairs of words from the same domain, which are closely related and have a similar level of difficulty so that they could be used in the pre- and post-testing. Version 1 vocabulary was used for pre-testing, Version 2 vocabulary was used for post-testing (see Vocabulary v1 and v2 in Table 1). The full vocabulary list (version 1 plus version 2) was used for learning and practicing.

Table 1. Vocabulary used in the experiments

Vocabulary v1	**Vocabulary v2**
Sun	Moon
Car	Bus
Fish	Seal
Bird	Duck

Shoes	Boots
Shark	Crab
Tree	Grass
Flower	Cactus
Butterfly	Dragonfly
JellyFish	Starfish

The vocabulary was selected with the agreement of two infant education teachers, in accordance with text and reading books in the official curricula at that educational level. We also wanted to include more than one domain to cover different topics in their educational curricula. The participants of the experiment had prior knowledge of this vocabulary because these domains had been introduced in class during the first and second semesters. The aim of our intervention was to revise, practice and improve their pronunciation during the third semester using different methods and approaches.

In order to test our initial hypotheses, we used quantitative data. In particular, we used a performance pre-post-test for testing H1 and a satisfaction survey and emotion analysis from photographs for testing H2. Figure 6 shows an overview of the five-week experimental procedure employed in this study.

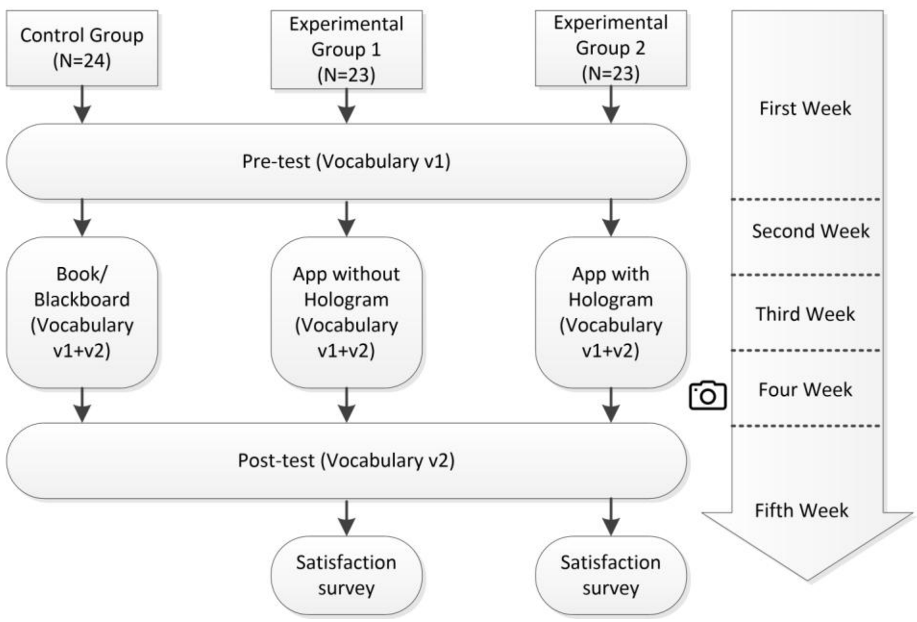

Figure 6: Diagram of experimental procedure.

At stage 1, all students completed a pre-test to evaluate their prior knowledge of the experimental content by using vocabulary version 1. At stage 2, learning activities using the full vocabulary list (version 1 plus version 2) were carried out in 30-minute sessions once a week for 3 weeks with each group using a different approach. All participants were taught and evaluated orally (listening and speaking) during the experiment. During instruction, children looked at drawings, pictures or 3D image holograms that represented each word and listened to the correct English pronunciation of each word modeled by the instructor or the Arturito hologram. During evaluation, they tried to correctly pronounce each word in English that they saw in picture cards.

Experimental groups EG1 and EG2 interacted with the corresponding app (EG1 with the mobile phone app and EG2 with the 3DHT app). The first week was spent introducing the mobile-based application by using the learn mode in which Arturito introduced all the items from the full vocabulary list. The following two weeks were spent learning and practicing the vocabulary by using the sequential and random practice modes. In the first week Arturito asked for items from the full vocabulary list in sequential order and the second week in random order. That is, all the 2D images or 3D images that represent the full vocabulary appeared in sequential or random order. During each one of these three sessions, each child interacted with the application in turns for about 5 minutes (about 15 minutes during the three weeks) while the others observed and remained quiet. The experiment was presented to the children as a very simple game/magic game as follows: You have to interact with a virtual teacher called Arturito to practice oral English vocabulary. You must to try to pronounce all the words we put into the box correctly, Arturito will ask you by showing you an image. If you do it well you win and will be able to see Arturito dancing.

During the same period, the CG used the images in books and on the board. The sequence of introducing and learning was the same: the first week was used to revise the full vocabulary. The teacher used the board with pictures that represented each item from the full vocabulary list. The teacher pointed to each picture and pronounced it in English while students listened. The following two weeks were spent sequentially and randomly learning and practicing the vocabulary by using a book with images of the vocabulary (one image per page). In the first week, the teacher asked for items from the full vocabulary list using images from the book in sequential order, that is, from the first page to the last page of the book. The teacher pointed at each image of the book, asking the children for the corresponding word. The following week, the teacher asked for items from the full vocabulary list randomly. The teacher opened the book on a random page and pointed to the image each time, asking for the word. If the image had already been seen by that student, the teacher continued opening pages at random until a new itme was shown.

The same teacher conducted the different sessions in the four subgroups from each class, while an additional teacher stayed with the rest of the children in class. The experiment was carried out in a similar environment and in a classroom next to the students' normal classroom in order to ensure that the children did not feel awkward being out of their class. Another additional researcher (as a non-participant observer) took photographs of all of the children during the final practice session (fourth week) in order to observe students' emotions during classes with and without holograms. The aim of this was to have a quantitative measure to test the second hypothesis in addition to the satisfaction survey, measuring the level of positive emotions such as happiness during experiments by doing an emotion analysis of their faces.

At stage 3, all students completed a post-test to evaluate their post knowledge using vocabulary version 2. Finally, EG1 and EG2 completed a satisfaction survey about their experience using the App with or without Hologram in contrast to the traditional teaching mode. All the data about the experiment were directly managed and collected by the researchers.

4.3 Data Analysis and Results

4.3.1. Children's learning performance

In order to test the 1st research question -*children perform better when learning and practicing basic oral English vocabulary using a mobile-based application with or without a holographic game than using traditional methods?*- We measured the performance of the students using a pre-post-test experimental design. The pre-test and post-test performance assessment was individually done one week before the first session and one week after the last experimental session. The assessment consisted of a simple 10 playing-card (flashcards without text) question test, given non-sequentially where every correct answer counted as 1 point. So each child's final score was an integer value over 10. From the teacher's and the educational psychology expert‘s point of view, it seemed to be an objective way to measure their performance, due to the very young age of the sample. Both the pre-test and post-test were exactly the same for the three groups (CG, EG1 and EG2) and were carried out by the same teacher who carried out the experimental sessions.

The data contributed by the three experiments were analyzed to verify that there were no values outside of the scale, missing values, or parameters that indicated a clear non-normal distribution; a Levene's test on the samples from the three groups was conducted, and the homogeneity test showed no significant difference ($F = 0.269$, $p > 0.05$). The results of experiment about learning performance are given in Table 2.

The initial level in the pre-test is about 4 points in all groups. This shows that the children already had some knowledge of words in the pre-test as they had seen them in the first and second semester of the course. In the post-test the children´s performance increased significantly in all groups. The scores in the CG ($t=23.87$, $p<0.05$), EG1 ($t=21.10$, $p<0.05$) and EG2 ($t=29.73$, $p<0.05$) were statistically significantly different before and after the experiment. However, this increment was higher in the EG2 group (+2.95) than in the EG1 (+2.49) and CG group (+2.13). So, it seems that the children demonstrated greater improvements in learning performance when using the app with the hologram than without the hologram or traditional methods such as images in books and on the board. However, an inter-group analysis is necessary to contrast these differences.

Table 2. Descriptive statistics and paired-sample t-test for pre-test and post-test

Group	**Variable**	**Mean**	**SD**	**t**
CG (N=24)	Pre-test	3.95	0.95	23.87*
	Post-test	7.00	1.02	
EG1 (N=23)	Pre-test	4.04	1.33	21.10*
	Post-test	7.52	1.16	
EG2 (N=23)	Pre-test	4.13	1.05	29.73*
	Post-test	8.08	1.12	

*p<0.05

Next, we conducted an analysis of variances (ANOVA) on the pre-test in order to test whether there were significant differences between the three groups. Results of the one-way ANOVA on pre-test scores are shown in Table 3. This analysis ($F=0.13$, $p\geq0.05$) indicated that there was no significant difference in the three group’s levels of prior knowledge before the experimental teaching activities began.

Table 3. ANOVA results of learning achievement for the pre-test.

Variable	Source	Sum of Squares	Degrees of freedom	Mean Square	F statistic
Pre-test	Between groups	0.34	2	0.17	0.13*
	Within groups	84.52	67	1.26	
	Total	84.87	69		

*p<0.05

We also calculated the Cohen's d about the strength of the relationship between the CG and the two experimental groups based on the standard difference between the post-test means. Cohen's d between CG and EG1 (0.47) indicated that the effect size was moderate and Cohen's d between CG and EG2 (1.00) indicated that the effect size was large.

Finally, we conducted an analysis of covariance (ANCOVA), using the pre-test levels as covariates in order to statistically control the effect of the initial level of knowledge on the post-test level and to obtain more accurate information about the effect of the holographic technology in learning. The results of ANCOVA are shown in Table 4

Table 4. ANCOVA results of the learning achievement for the post-test

Source	Sum of Squares	Degrees of freedom	Mean Square	F statistic	Ad Hoc
Adjusted means	10.56	2	5.28	12.397*	EG1 > CG EG2 > CG EG2 > EG1
Adjusted error	28.11	66	0.426		
Adjusted total	38.67	68			

*p<0.05

The data provided by the ANCOVA showed statistically significant differences between groups, ($F_{(2, 66)} = 12.397$, p<.001, $\eta_p^2 = .273$). These results also provide information about the autoregressive effect of the variable, in other words, the capacity of the pre-test levels to predict the post-test levels of the performance, $F_{(1, 66)} = 53.455$, p< .001, $\eta_p^2 = .655$. As can be seen, previous knowledge of English seems to be a variable that is not easy to change and very strongly influenced by its high pre-test level; in this sense, the level of previous knowledge could be obscuring the true potential of the hologram technique. Nevertheless, it is revealing to check the differences between the three groups. The comparison shows that the post-test scores of the CG and EG1, and CG and EG2 are significantly different $MD_{(CG-EG1)} = -.454$, p< .05; $MD_{(CG-EG2)} = -.950$, p< .001 , and that the post-test scores of EG1 and EG2 are also significantly different ($MD_{(EG1-EG2)} = -.496$, p< .05). In summary, the results of our study about learning performance show that although the three groups improved their knowledge of oral vocabulary in English, EG2 scored significantly higher than EG1 and the CG did. This could presumably be attributed to the holographic component and its capacity to increase student's motivation and encourage learning in the classroom over the already typical mobile-based applications and traditional methods such as using images in books and on the board.

4.3.2 Children 's satisfaction and emotions

In order to test the 2nd research question -*children show that they prefer using a mobile-based application with or without a holographic game for learning and practicing oral English vocabulary rather than the traditional methods used in the classroom*- we used two methodologies, a satisfaction survey and an emotion analysis.

We developed a specific satisfaction survey to ask children from the EG1 and EG2 groups about their experience using the App for learning. First, both EGs were asked about their satisfaction compared with regular teaching methods (See Dimension A) because of the well-known importance of motivation in every kind of learning (Schunk & Zimmerman, 2012; Schunk, Meece, & Pintrich, 2012). We only asked to children from EG1 and EG2 because both have daily experience with books and blackboard, and the learning procedure in the CG was the normal procedure (using images in books and on the board). Then we wanted to focus on the hypothetical differences in satisfaction with holographic technology between EGs. We asked EGs again about the learning experience specifically to check if there were any differences in terms of satisfaction between mobile and holographic technology (See Dimension B). For this dual purpose we carried out a very specific and simple ad hoc satisfaction survey due to the early age and self-report skills of the participants; its Cronbach's alpha is 0.88. The survey consisted of six questions in a 3-point Likert Scale (0=A litle, 1=Some, 2=A lot) about two dimensions: learning experience satisfaction in comparison with traditional methodology and general experience satisfaction.

Dimension A. *How much they like Arturito compared with traditional methods*

A1. English classes are better since they are with Arturito instead of books and the board.

A2. Arturito is cooler than books and the board.

A3. I want Arturito to teach me more stuff instead of using books and the board.

Dimension B. *How much they like Arturito*

B1. I like Arturito

B2. Arturito is funny

B3. I would like Arturito to teach me for a longer time.

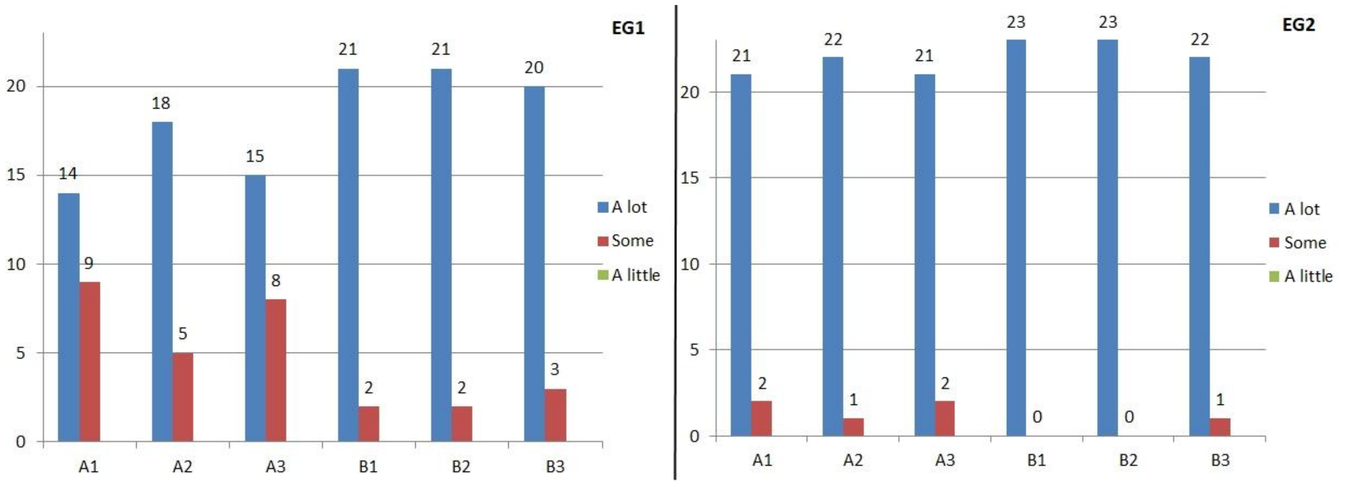

Figure 7: Frequency analysis of EG1 and EG2 answers´ in satisfaction survey.

The teacher asked each student the six questions giving them the 3 answer options and recorded their answers in a file. Figure 7 shows that EG2 scored higher values than the EG1 group in every item, especially in dimension B questions where was being tested the differences in terms of satisfaction between mobile and holographic technology. In EG2, almost all the children (between 21 and 23) scored the highest value on the scale at all questions and only 1 or 2 children answered “Some” in some items (A1, A2, A3 and B3). In EG1, between 14 and 21 children scored the highest value “A lot” at all the questions and between 2 and 9 children answered “Some” to the questions. Therefore, it seems that satisfaction was very high in general, but slightly more in EG2 than in EG1.

Table 5 shows the descriptive statistics and t-test of the satisfaction survey in EG1 and EG2. The results about preference for Arturito over traditional methodology (see Table 4), are higher in EG2 (Dimension A: M=1,92, SD=0,25) than EG1 (Dimension A: M=1,69, SD=0,46) (see Table 4). In this dimension, question A2 yielded the highest mean score in both groups, providing evidence that children think that Arturito is cooler than traditional methods. The average sense of satisfaction with Arturito was very high in both groups. However, this result was higher in EG2 (Dimension B: M=1,98, SD=0,06) than EG1 (Dimension B: M=1,89, SD=0,29). In this dimension, questions B1 and B2 yielded the highest mean scores in both groups, providing evidence that children like Arturito. In fact, all the EG2 children answered these two questions with the highest value on the scale.

We also used a t-test in order to examine whether there were differences between the mean scores in each question. We found that there were no significant differences between EG1 and EG2 scores in questions B1 ($t=-1.41$, $p<0.05$), B2 ($t=-1.41$, $p<0.05$), B3 ($t=-0.99$, $p<0.05$) and A2 ($t=-1.70$, $p<0.05$), but there were significant differences in A1 ($t=-2.42$, $p<0.05$) and A3 ($t=-2.11$, $p<0.05$). So in general, both groups expressed the idea that they liked Arturito and it is cooler than traditional methods without significant differences. But, EG2 children were statistically significantly more satisfied than EG1 children with the holographic Arturito teaching them more than just vocabulary rather than using images in books and on the board.

Table 5. Descriptive statistics and t-test for satisfaction survey in EG1 and EG2.

Dimension	**Question**	**Group**	**Mean**	**SD**	**t**
A	**1**	EG1	1.62	0.49	-2.42*
		EG2	1.91	0.28	
	2	EG1	1.79	0.41	-1.70*
		EG2	1.95	0.20	
	3	EG1	1.66	0.48	-2.11*
		EG2	1.91	0.28	
B	**1**	EG1	1.91	0.28	-1.41*
		EG2	2	0	
	2	EG1	1.91	0.28	-1.41*
		EG2	2	0	
	3	EG1	1.87	0.33	-0.99*
		EG2	1,95	0.20	

Finally, we carried out an emotion analysis in order to measure children´s positive emotions. We analyzed photos of the three groups during the experiment to study the emotions of the children. A additional instructor (non-participant observer) was responsible for taking those images using their own smartphones. They took photos of each student periodically during the 4th week at the middle and the end of each student‘s session (about minute 2.5 and 5 respectively of each turn). A total of 140 photos, 48 photos of CG, 46 photos of EG1 and 46 photos of EG2 were analyzed to observe emotions expressed in children´s faces in order to obtain more qualitative information about their levels of satisfaction. In order to analize emotions through images we used the Microsoft Emotion API (https://www.microsoft.com/cognitive-services/en-us/emotion-api) also known as the Oxford emotion API. We selected this specific API because it can be used to detect not only a face but also a grouop of faces (the maximum number of faces is 64) and it has been previously used successfully in other educational research (Khalfallah at al. 2017, Saneiro et al. 2014, Takac et al. 2016, Weber et al., 2016, Bharatharaj et al, 2017). The Emotion API uses multilayered deep learning technology to return confidence across a set of emotions for each face in the image, as well as a bounding box for the face. The emotions detected are anger, contempt, disgust, fear, happiness, neutral, sadness, and surprise. The same length emotions vector is also returned by other online facial emotion recognition application program (Takac et al. 2016). It is necessary to note that the original vector provided from the Microsoft Emotion API consisted of eight emotions instead of seven in the classic Ekman's model (Ekman, 1992). This is. because of the addition of the contempt emotion. These emotions are understood to be cross-culturally and universally communicated with particular facial expressions. For example, two images of the same student's turn (EG2 subgroup 1) are shown below (See Figure 8). It was necessary to request informed consent from children´s parents in order to use the photos for the research proposal. For this reason, in Figure 8 we obscured the children's eyes following the emotion analysis to prevent them from being identified. The image on the left shows children in the middle of the session. In the image on the right (at the end of the session) the Emotion API was used in order to detect faces (indicated in rectangles) and show the emotions of the selected student (the girl in the center of the image).

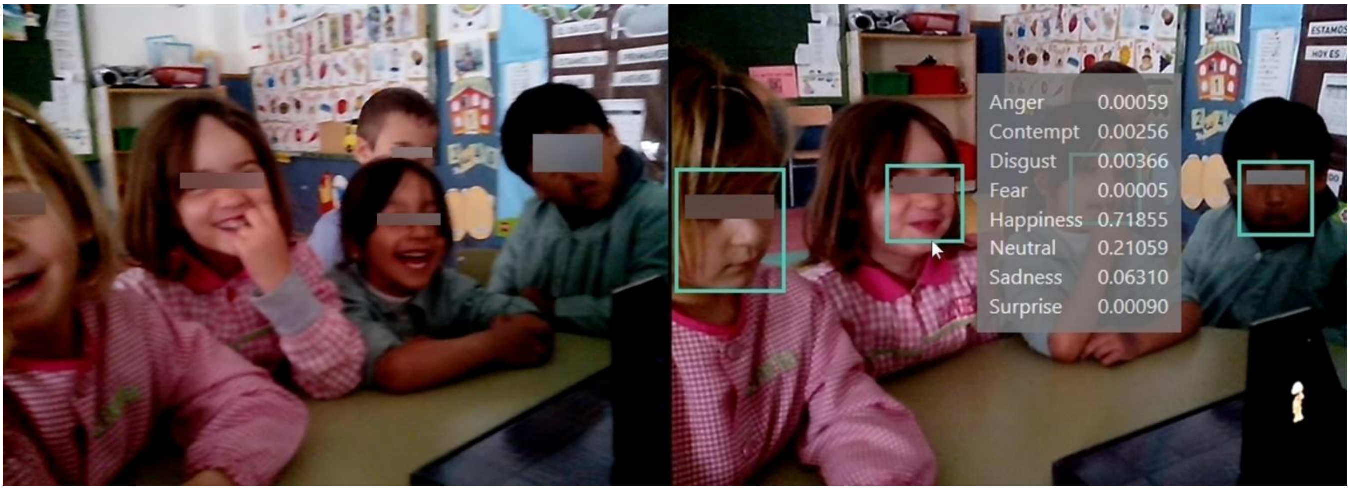

Figure 8: Images of EG2 subgroup 1 children during the experiment.

The Emotion API also returns a JSON (JavaScript Object Notation) file for each image with the number of faces detected, the coordinates about the location of faces in the image in pixels (left, top, width, and height) and the emotion values (normalized to sum one). We have used this information in order to obtain an aggregate result about emotions detected in all photos of each group. Table 6 shows the mean and standard deviation of the emotions detected for each group.

Table 6. Descriptive statistics and ANOVA for Children´s emotions in CG, EG1 and EG2.

Emotion	**Group**	**Mean**	**SD**	**F statistic**	**Post-hoc Games Howell**
Anger	CG	0.0030	0.0028	0.746	
	EG1	0.0031	0.0034		
	EG2	0.0039	0.0046		
Contempt	CG	0.0007	0.0004	2.337	
	EG1	0.0006	0.0003		

	EG2	0.0008	0.0004		
Disgust	CG	0.0008	0.0006	2.631	
	EG1	0.0014	0.0021		
	EG2	0.0009	0.0012		
Fear	CG	0.0010	0.0022	1.624	
	EG1	0.0008	0.0011		
	EG2	0.0004	0.0004		
Happiness	CG	0.3123	0.1788	47.359*	EG2>EG1
	EG1	0.4804	0.1585		EG2>CG
	EG2	0.6190	0.1129		EG1>CG
Neutral	CG	0.6667	0.1857	58.829*	CG>EG1
	EG1	0.4903	0.1574		CG>EG2
	EG2	0.3210	0.1089		EG1>EG2
Sadness	CG	0.0071	0.0053	6.636*	CG>EG2
	EG1	0.0051	0.0046		
	EG2	0.0038	0.0029		
Surprise	CG	0.0085	0.0078	28.200*	EG2>EG1
	EG1	0.0184	0.0089		EG2>CG
	EG2	0.0504	0.0475		EG1>CG

*p<0.05

We can see in Table 6 that there are two prominent emotions in the three groups, happiness and neutral, but our goal is check if there are significant differences according to whether holographic technology for learning is used or not. According to Wilks Lambda (λ = .375; $F_{(16, 260)}$=10.300; p<.001; $\eta^2_{p=}$.388) there were differences between groups in that group of emotions. Those differences were found in only four of the emotions: happiness ($F_{(2, 137)}$=47.359) p<.001; $\eta^2_{p=}$.409), neutral ($F_{(2, 137)}$=58.829; p<.001; $\eta^2_{p=}$.462), sadness ($F_{(2, 137)}$=6.636; p<.01; $\eta^2_{p=}$.088), and surprise ($F_{(2, 137)}$=28.200; p<.001; $\eta^2_{p=}$.292). To check which groups were those differences were between we performed a multivariate ANOVA and post-hoc analysis. Prior to that, in order to verify the equality of covariance matrices we carried out Box‘s Test to test the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups. Results showed that Box´s M was statistically significant so we should assume that there were differences and choose an appropriate post-hoc test. According to Games-Howell there were statistically significant differences between every group in happiness, neutral, and surprise (p<.001), and between CG and EG2 in sadness; mean values were EG2>EG1>CG for happiness and surprise, and CG >EG1>EG2 for neutral and sadness.

Additionally, teachers were briefly interviewed and asked to provide some feedback about the children‘s behavior during the experiment. They asserted that the children showed a great deal of interest in Arturito. They informed us that, in general, EG1 and EG2 children looked happier in each session and they seemed more focused and engaged than CG children. They also stated that children were excited before the sessions when they knew that they were going to interact with Arturito.

Above all, most of the EG2 children asked to play with the hologram game again even some weeks after the experience. Informal observation by their normal teacher suggested that some of the less participative children in the traditional learning sessions interacted more easily with the hologram than with the teacher. The teacher also reported that both groups (EG1 and EG2 children) laughed and smiled a lot during all the sessions with Arturito. Especially the EG2 children who seemed to be the most excited.

5.Discussion and Conclusions

In this study, we used a very simple game in which children have to speak with a virtual teacher called Arturito. We used speech recognition to interact with children and to practice English word pronunciation. The goal of the game was to learn and correctly pronounce all the words asked for by Arturito as quickly as possible in order to see him dancing. It is also important to note that our mobile-based application is not a typical game-based learning application because it is an adaptation of a magic trick game. We used a hologram illusion (3D realistic image with movement) that appears real. A robot Hologram acts as an instructor teaching words in English using 3D images with movement.

The results from the pre-post-test experiment confirm that the children performed better when learning and practicing basic oral English vocabulary using a mobile-based application with a holographic game than when using the traditional methods such as using images in books and on the board. The EG2 children not only had the highest scores of the three groups but there were also significant differences compared to the CG. This may be attributed to the holographic element that could be increasing students‘ motivation and interest in learning more than merely mobile-based applications and traditional methods. Looking back at previous research this is not surprising. The results are also in the line with Mnaathr, and Basha, (2013) who found that children learned science topics earlier in their educational lives with the application of 3D models. In addition to the game‘s inherent power in learning, motivating through fun, ‘part of the natural learning process in human development’ (Bisson and Luckner 1996); what is innovative in this case is the application of holographic technology to EFL at an early age.

The results from the satisfaction survey confirm that the children enjoyed learning and practicing oral English vocabulary using the applications developed for this study, and that they preferred using them over traditional methods. Children in both EGs were more satisfied with Arturito in his two versions than with traditional teaching methods. Additionally, the children in the holographic group scored Arturito significantly higher than traditional methods and their scores indicated that they would like that him to teach them more “stuff“ going beyond the use of images in books and the board. Again, this is not surprising as holographic technology is a novelty that provides a rich variety of graphic representations to generate more realistic scenarios and is literally using technology to represent reality and embody fantasy. The teacher informally talked to the kids about the holographic version of Arturito and was given answers like “Arturito is alive”, “he is real”, “it is more fun than the phone”, “he is a robot ghost”, “I love when he sings and dances”, or “it is like magic”. This chimes with the idea of students seeking of new ways to learn and our perception of the hologram as a new learning tool that increases learning (Golden, 2017).

The teacher informally reported that most of the EG2 children asked to play with the hologram game again even some weeks after the experience, and that some of them, especially those who participate less in traditional learning sessions, interacted more easily with the hologram than with the instructor. Although this information comes from an informal observation it does shed some light on one of the major challenges when intervening in learning, which is the difficulty of maintaining positive intervention effects over time (Melnyk & Morrison-Beedy, 2012). The instructor also reported that, in general, children seemed very happy, focused, interested and engaged when using the hologram game. Although this observation would need systematization and further investigation, this preliminary evidence is consistent with previous research (Annetta et al., 2009).

The most remarkable gains that the teacher reported were in terms of attention, engagement, and curiosity. In line with the results from Durango (2015), the teacher stated that the hologram kept those children that have some attention difficulties in the regular learning sessions focused on the task. It is not surprising to achieve cognitive outcomes when using games for learning (Boyle et al., 2016). Children learn through playing games because this is the easiest way for them to imagine and connect with objects and the world around them, so whenever a game is introduced in language classes, students' motivation is thought to increase based on common sense (Yiltanhhlar & Kivanc, 2015). Additionally, the art of magic has the potential to amaze and capture and hold the attention of people of all ages (Spencer, 2012). In this regard, the analysis of emotions in children's photos during the sessions suggested that children using the application with the holographic game demonstrated more happiness and surprise and less sadness and neutral emotion than those using only the smartphone or the traditional teaching methods. It is easy to guess the effect of happiness on learning (Csikszentmihalyi, 2014) or emotions identified in previous research as low in arousal, such as neutral feelings and boredom (Harley, Bouchet, Hussain, Azevedo, & Calvo, 2015). It is much more challenging to reflect on previous results showing that positive emotions foster academic achievement only when they are mediated by motivation (Mega, Ronconi, De Beni, 2014). Previous research has also shown that holograms seem to arouse curiosity in children, and people are better at learning information that they are curious about (Gruber, Gelman, & Ranganath, 2014). Although it may sound banal, this emotional-motivational state has an important role when acquiring knowledge and making the process pleasurable (D'Mello, 2012; Litman, 2015). Other results have shown that academic emotions are significantly related to students' motivation, learning strategies, cognitive resources, self-regulation, and academic achievement (Pekrun, Goetz, Titz, & Perry, 2002). The findings indicate that affective research in educational and computer science should acknowledge the role of emotional importance in academic settings by addressing the study of the full range of emotions experienced by students when introducing cutting edge educational methods. It is interesting to note that we only took photographs in the final session (week four) in order to avoid the effect of novelty from the technology. The users of mobile, technology games, and other types of computer-based instruction experience a transient effect because of their novelty (Kulik and Kulik, 1991).

Much more research needs to be conducted before concluding that a hologram is better than a teacher or can substitute for a teacher, something that is not the horizon of the current work, but this approach could be a radical change in instructional style based on ICTs applied to education. The greatest promise of educational software is not teaching efficiency but altering the curricula, and the core contribution is not so much the teaching as the child's learning process. In line with this, introducing tools such as Arturito in educational settings could reduce training time and instructor load, affording opportunities for drill and practice, for example. Additionally, these kinds of technologies enable students to be more responsible and self-regulated, and this could be a relief for teachers who have been trying to achieve this since the constructivist approach to learning emerged (Fat, 2000). In fact, a holographic resource could be understood as a cutting-edge evolution of the already traditional means like blackboards, text books, playing cards, and interactive whiteboards. Therefore, the potential of a projected 3D image in technical (portability, personalization, etc.) and learning terms (novelty, gamification, etc.) is extremely promising.

The study is subject to some limitations. We are aware of the assessment methodology used. The performance tests only inform us about the children´s declarative knowledge. In addition, a self-informed survey to measure satisfaction and the methodology preference in the sample is only valid as a preliminary result. Considering the potential of holograms for learning, it would be interesting to systematically explore other core variables in learning such as metacognition, self-regulation, or the motivational spectrum. In addition, aspects for providing a more personalized gaming experience to sustain the engagement of the players with the game may be considered. For that reason, one of our future plans is to implement observational video tools in order to test and improve the learning experience. While there are methodological difficulties with this methodology, an observational video instrument would allow us to make more valid assessments of children's cognitive and metacognitive processes during learning with the hologram, and not be restricted to just the result. Currently, the work from Whitbread and colleagues is heading in this direction, constructing and developing observational instruments from recording early aged child ‘events' that are very helpful for our approach (Whitebread et al., 2009; Whitebread and Coltman, 2015; Whitebread et al., 2009). Furthermore, the Flow Theory approach will undoubtedly improve the experience when practicing, particularly in the sequential and random modes. Flow theory is a new subject worth considering in EFL learning (Guan, 2013). An interesting future prospect for this work is to dynamically adapt the game to balance it to every child‘s skill level and the challenge of the task. When a task is too difficult, it might make the child anxious, when a task is too easy, that may end up in inattentiveness or boredom. When the task is just right, children are focused and immersed in the learning process, a state of flow that seems to be useful for sustaining the engagement of the player with the game (Sajjadi, Van Broeckhoven, & De Troyer, 2014).

Another limitation is the quasi-experimental nature of using existing classes. The next steps are to replicate the experiment using a strict experimental design, in which children would be randomly assigned to classes. We also want to increase the sample and the English skills contained in the pre-school curricula. As well as this, bearing in mind the empirical results, increasing the difficulty of the learning material would probably give us more information about instructional practice. As observed, the children’s pre-test scores were already quite good for every group, therefore, the potential progress that could be achieved by the EGs is lower and harder to achieve than if the margin were bigger. The good news is that with a simple software improvement, the student can deal with practically limitless content and be faced with differing levels of challenge, tasks can be instantly updated, customized and modified by teachers or even individual players, so that the player becomes part of the creative team. However, one must remember that computer games for learning are particularly effective when addressing a specific problem or teaching a certain skill (Griffiths 2002), for example in encouraging learning in curriculum areas such as maths, physics and languages, where specific objectives can be stated (Randel, Morris, Wetzel, & Whitehill 1992).

Another, unfortunately typical limitation of this kind of work is that we do not know how long our intervention results are sustained for. However, this is not a core aspect in our study as we are not proposing a remedial intervention but a tool to introduce in the teaching-learning routine. Moreover, we conducted the post-test one week after the experiments trying to test long-term memory and avoiding immediate transience, or forgetting that occurs with the passage of time. In the future, it would be necessary to take repeated measures to test the effect of the hologram on both learning and levels of motivation over time. In a large number of similar studies on EFL vocabulary learning post-tests were administered immediately after experiments (Agca and Ozdemir, 2013, Ashraf et al. 2015, Mashhadi and Jamalifar, 2015). Raiche (2011) proposed waiting at least 24 hours or ideally a few days to test long-term retention but only a proportion of research into second language vocabulary learning administered multiple post-tests. Two post-tests, two days later and one week later were conducted to check if the effect was maintained over time by Barcroft (2007), and three retention tests were carried out in another related study: one the day after the last practice, four weeks after the last practice, and eight weeks after the last practice by Schuetze (2017). This kind of tracking is also supported by language instructors (Oxford, 1990).

Finally, with respect to the software application and hologram, some technical improvements are already being made to improve the learning experience; the size of the hologram and the the volume of the hologram´s voice. Currently, the hologram could be bigger and its voice louder, allowing larger student groups. For example, we could use a tablet instead of a smartphone and we could use an additional speaker. These simple improvements would make the experience smoother for using in a class/group with more students. In conclusion, we recognize that mobile-based applications and holograms are not a panacea but if innovative technologies are more engaging and appealing to students and if, in turn, these learners are more motivated to interact with these learning environments than with traditional materials, then this in itself may justify the use of and deeper investigation into these resources.

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Table 1

TABLE 1
VOCABULARY USED IN THE EXPERIMENTS.

Vocabulary v1	**Vocabulary v2**
Sun	Moon
Car	Bus
Fish	Seal
Bird	Duck
Shoes	Boots
Shark	Crab
Tree	Grass
Flower	Cactus
Butterfly	Dragonfly
JellyFish	Starfish

Table 2

Table 2
Descriptive statistics and paired-sample t-test for pre-test and post-test.

Group	Variable	Mean	SD	t
CG (N=24)	Pre-test	3.95	0.95	23.87*
	Post-test	7.00	1.02	
EG1 (N=23)	Pre-test	4.04	1.33	21.10*
	Post-test	7.52	1.16	
EG2 (N=23)	Pre-test	4.13	1.05	29.73*
	Post-test	8.08	1.12	

*$p<0.05$

Table 3

Table 3
ANOVA results of the learning achievement for the pre-test.

Variable	Source	Sum of Squares	Degrees of freedom	Mean Square	F statistic
Pre-test	Between groups	0.34	2	0.17	0.13*
	Within groups	84.52	67	1.26	
	Total	84.87	69		

$^*p<0.05$

Table 4

Table 4
ANCOVA results of the learning achievement for the post-test.

Source	Sum of Squares	Degrees of freedom	Mean Square	F statistic	Ad Hoc
Adjusted means	10.56	2	5.28	12.397*	EG1 > CG EG2 > CG EG2 > EG1
Adjusted error	28.11	66	0.426		
Adjusted total	38.67	68			

*p<0.05

Table 5

Table 5

DESCRIPTIVE STATISTICS AND T-TEST FOR SATISFACTION SURVEY IN EG1 AND EG2.

Dimension	Question	Group	Mean	SD	t
A	1	EG1	1.62	0.49	-2.42*
		EG2	1.91	0.28	
	2	EG1	1.79	0.41	-1.70*
		EG2	1.95	0.20	
	3	EG1	1.66	0.48	-2.11*
		EG2	1.91	0.28	
B	1	EG1	1.91	0.28	-1.41*
		EG2	2	0	
	2	EG1	1.91	0.28	-1.41*
		EG2	2	0	
	3	EG1	1.87	0.33	-0.99*
		EG2	1,95	0.20	

*p<0.05

Table 6

TABLE 6
DESCRIPTIVE STATISTICS AND ANOVA FOR CHILDREN´S EMOTIONS IN CG, EG1 AND EG2.

Emotion	Group	Mean	SD	F statistic	Post-hoc Games Howell
Anger	CG	0.0030	0.0028	0.746	
	EG1	0.0031	0.0034		
	EG2	0.0039	0.0046		
Contempt	CG	0.0007	0.0004	2.337	
	EG1	0.0006	0.0003		
	EG2	0.0008	0.0004		
Disgust	CG	0.0008	0.0006	2.631	
	EG1	0.0014	0.0021		
	EG2	0.0009	0.0012		
Fear	CG	0.0010	0.0022	1.624	
	EG1	0.0008	0.0011		
	EG2	0.0004	0.0004		
Happiness	CG	0.3123	0.1788	47.359*	EG2>EG1
	EG1	0.4804	0.1585		EG2>CG
	EG2	0.6190	0.1129		EG1>CG
Neutral	CG	0.6667	0.1857	58.829*	CG>EG1
	EG1	0.4903	0.1574		CG>EG2
	EG2	0.3210	0.1089		EG1>EG2
Sadness	CG	0.0071	0.0053	6.636*	CG>EG1
	EG1	0.0051	0.0046		CG>EG2
	EG2	0.0038	0.0029		EG1>EG2
Surprise	CG	0.0085	0.0078	28.200*	EG2>EG1
	EG1	0.0184	0.0089		EG2>CG
	EG2	0.0504	0.0475		EG1>CG

*p<0.05

Figure 1
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Figure 2

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Figure 3
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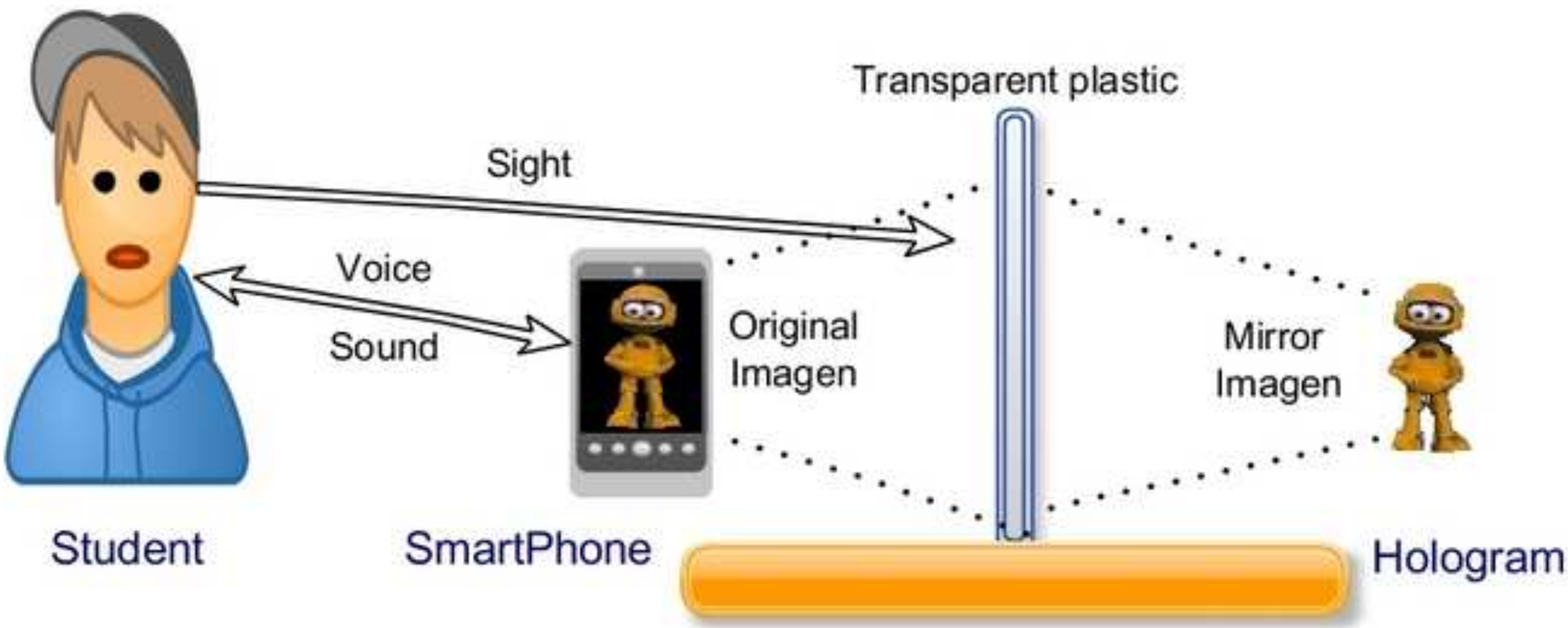

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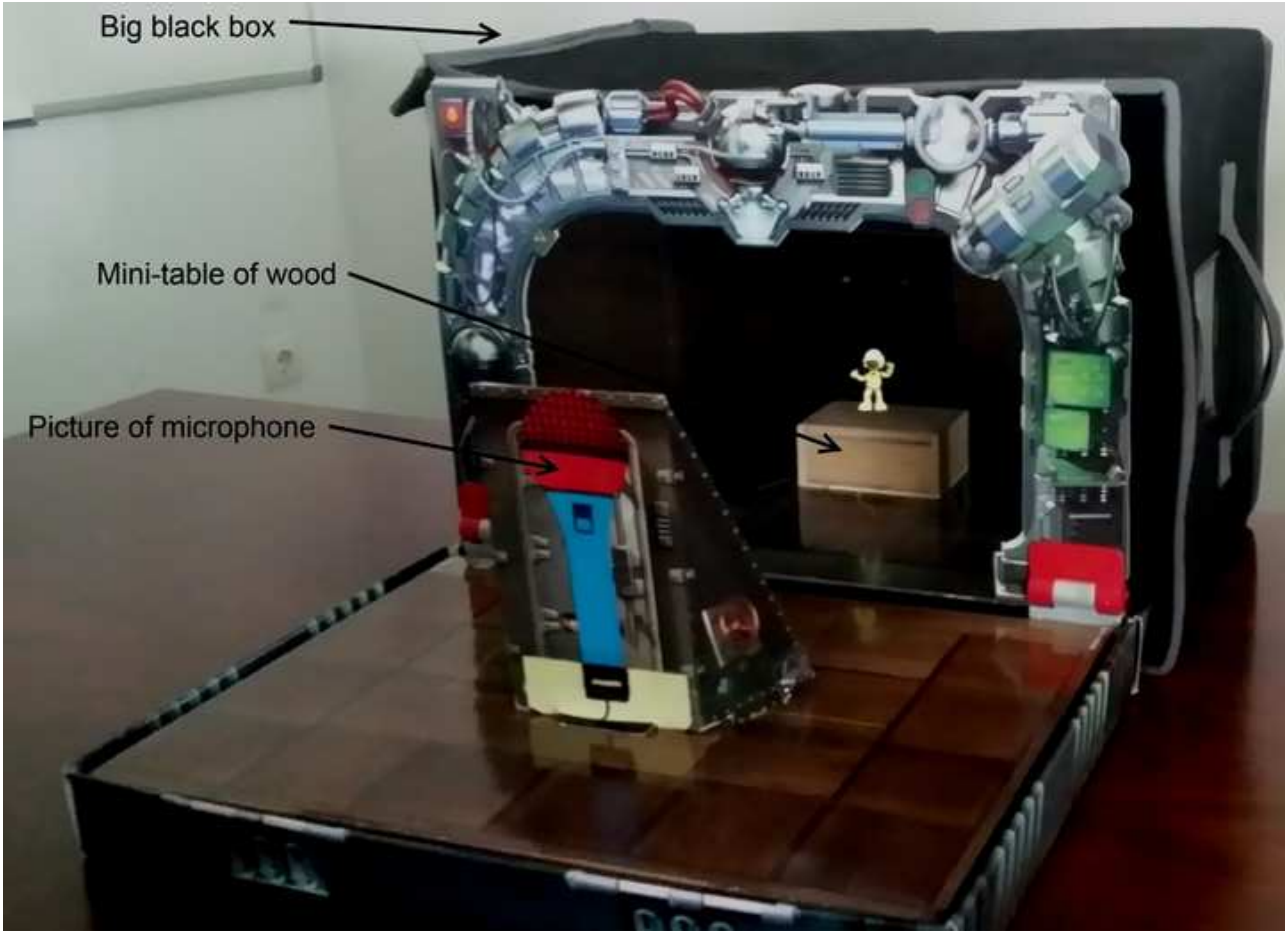

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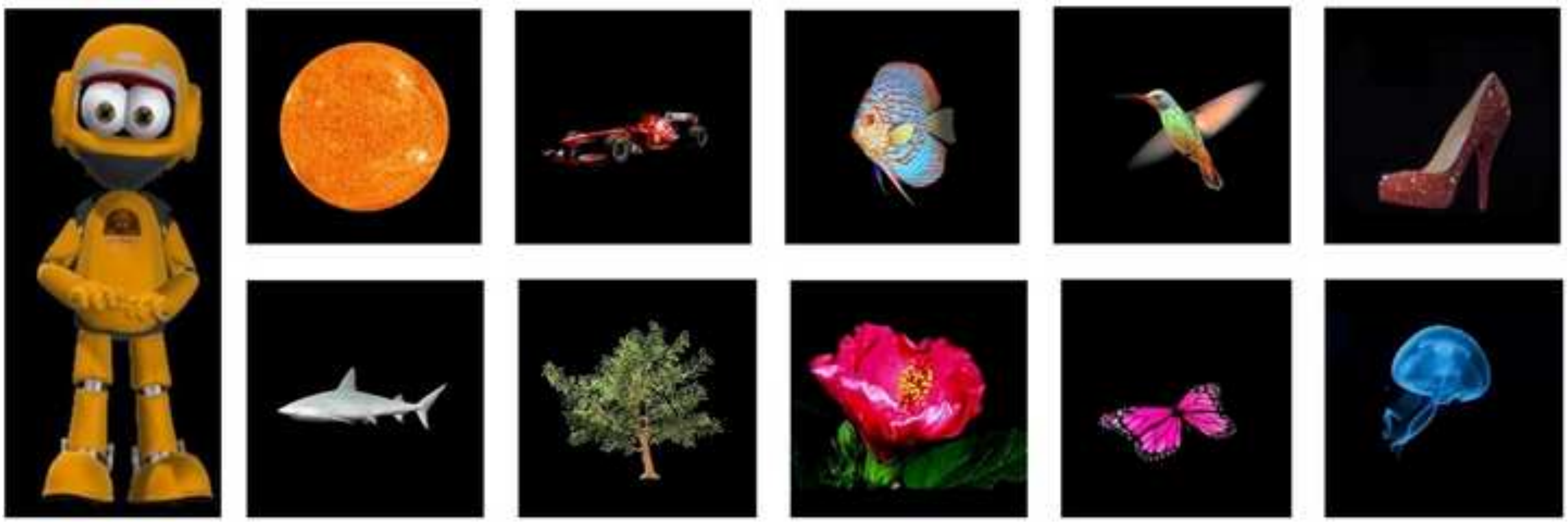

Figure 6

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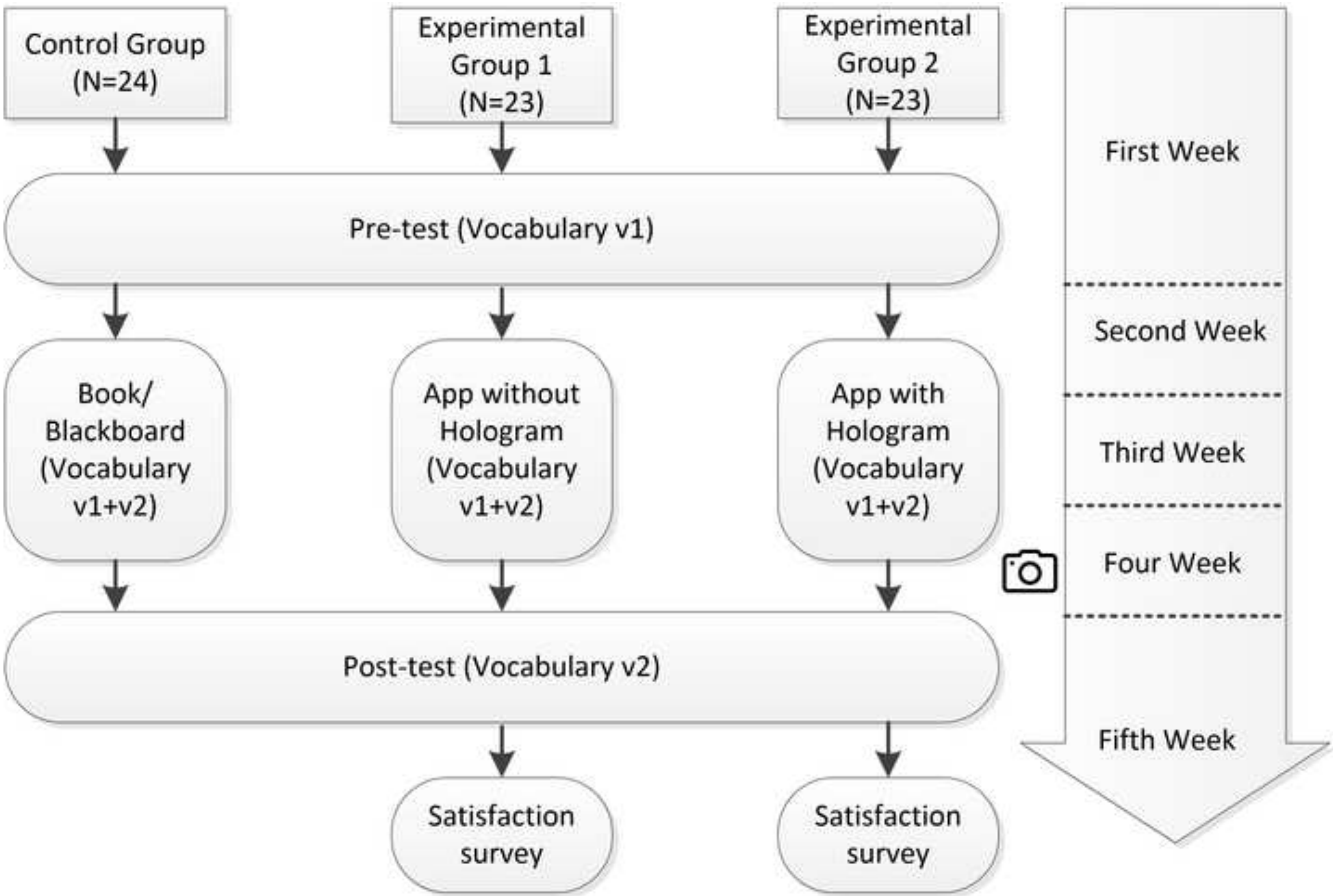

Figure 7
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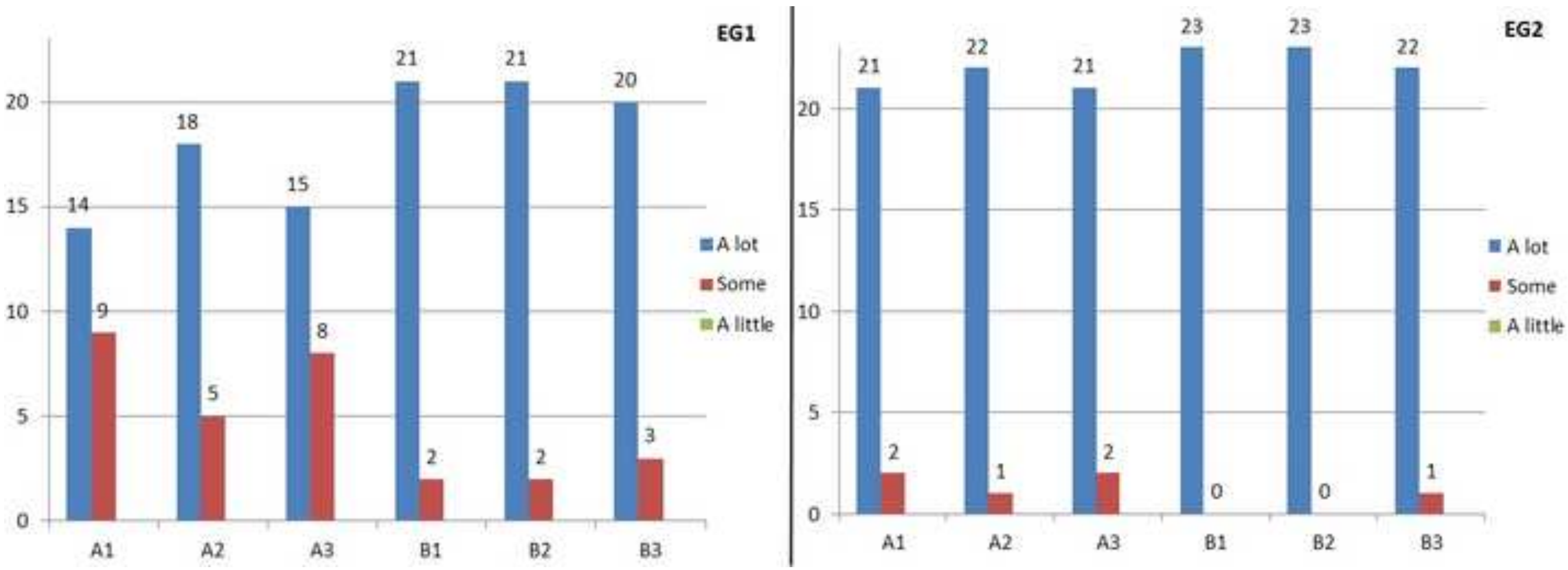

Figure 8
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