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Improvement of Memory and Motivation in Language Learning in Primary Education through the Interactive Digital Whiteboard (IDW): The Future in a Post-Pandemic Period

José M. Bautista-Vallejo [1], Rafael M. Hernández-Carrera [2], Ricardo Moreno-Rodriguez [3,*] and José Luis Lopez-Bastias [3]

[1] Department of Pedagogy, University of Huelva, 21007 Huelva, Spain; bautista@uhu.es
[2] Department of Didactics and School Organization, Universidad Internacional de La Rioja, 26002 Logroño, Spain; rafael.hernandez@unir.net
[3] Department of Educational Sciences, University Rey Juan Carlos, 28032 Madrid, Spain; joseluis.lopez@urjc.es
* Correspondence: ricardo.moreno@urjc.es; Tel.: +34-646-816-518

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Abstract: This paper presents an analysis of the use of an interactive digital whiteboard (IDW) and a computer application called Action Manager (AM), with a sample of 158 sixth-grade students in primary education. Subsequently, a study was carried out with the main goal of testing the didactic functioning of AM and examining the validity of this application, in terms of motivation and the retention of both short and long-term memory when teaching foreign languages in primary education. In order to fulfil these objectives, we performed a positivist exploratory study based on a quantitative methodology combining qualitative aspects (qualitative evaluation) and quantitative aspects (questionnaires) as well as a descriptive method with a survey design. The data collection was performed using instruments, specifically the Extrinsic vs. Intrinsic Orientation Scale, to ascertain the motivational impressions of the students and two memory tests, the Test of Memory and Learning (TOMAL) and the Children's Memory Scale (CMS). Forty-five days later, the two memory tests were repeated to compare the results with the previous ones. After this experience, the results allowed us to conclude that the students demonstrated optimal memorization from a conceptual point of view, in addition to having improved their motivational impressions.

Keywords: interactive digital whiteboard; memory; motivation; language learning; ICT

1. Introduction

The application of information and communication technologies (ICT) for foreign language learning started as a great novelty and has great promise. Over the years, this situation has been normalized [1,2]. That is to say, the use of these technologies has allowed a new way of seeing and managing teaching–learning processes. Today, even though certain barriers exist, the use of these fundamentally computer-based processes has become more and more natural and even necessary.

There are many tools that have been used since the beginning of the technologicalization of teaching and learning. The advent of information technology is bringing about a real transformation in this area. One of these instruments is the interactive digital whiteboard (IDW), a touch interface connected to a computer, which allows not only writing or drawing as on a traditional blackboard, but also inserting and dragging images, navigating or highlighting on the screen. Gradually, the IDW has become one of the most comprehensive and innovative resources for teaching [3].

On the other hand, along with the fact that the main problem, which affects language learning, can be related to the use of an obsolete and inadequate methodology, other aspects, such as the lack of interest and motivation of students, are being put forth as the key to the development of the teaching–learning process. Thus, these aspects are pivotal for teaching staff [4,5].

In this sense, from the beginning of the inclusion of computer technologies, the use of hardware and software allowed the development of different strategies in the foreign language classroom to improve levels of motivation and interest [6], such as explanations supported by images, animations, the use of websites and specialized applications, the viewing of films, documentaries, etc. [7] as well as the use of a text processor offline and online, among others. All of these aspects have helped to more successfully tackle the problem of the interest and motivation of students [8].

In other words, digital resources have been acquiring importance in education insofar as they help the integral development of students, through interactive digital materials that generate motivation and also learning [9].

The COVID-19 disease, caused by the SARS-CoV-2 coronavirus, has been a differential factor in the inclusion of digital technologies in educational institutions during this time. In Spain, a state of alert was established wherein non-attendance education has jumped exponentially. In this scenario the suspension of classes has not adversely affected student training for the time being. The effect, however, is full of unknowns [10].

In this situation, the fundamental elements that will be affected in educational institutions are varied: firstly, the technological and administrative aspects, and, on the other hand, the pedagogical and the communicative ones, generating a totally new situation in the midst of accelerated measures towards virtual forms of teaching–learning [11–13].

Naturally, this situation will imply managing teaching–learning processes with the assistance of digital technologies, many of which will break the hegemony of the in-person method until the establishment of more hybrid or totally remote models.

In this sense, the evaluation of increasingly common practices during the pandemic period, and even in a post-pandemic period, is of great importance. This is how the interest arises in evaluating the Action Manager® (AM) application and its impact on motivation and different types of memory during the present time, when digital technologies have become predominant.

Within this framework, the purpose of this study is to describe the operation of the Action Manager® (AM) application, which has become a pioneering interactive digital whiteboard software for learning foreign languages, specifically for learning actions and vocabulary that favor English language communication in the classroom [14].

With the specific objective of studying the didactic and pedagogical efficiency of AM, an experiment using this application was developed with primary education students, within the scope of evaluative research intended to ascertain the motivational impressions of the students through an Extrinsic vs. Intrinsic Orientation Scale, and to determine to what extent these students retained the vocabulary words of the application in the short and long term. To this end, two types of memory tests were carried out (the Test of Memory and Learning (TOMAL) and the Children's Memory Scale (CMS)).

The Test of Memory and Learning (TOMAL) aims to assess memory in children from 5 to 19 years old. Specifically, five fields are obtained: verbal memory, non-verbal memory, compound memory, delayed memory and learning. The Children's Memory Scale (CMS) test assesses various aspects of memory in children from 5 to 16 years old. Specifically, it assesses verbal memory, visual memory, short-term memory, long-term memory, working memory, and attention.

2. Theoretical Framework

2.1. Advantages and Disadvantages of ICT Inclusion in Education

Despite the fact that the inclusion of digital resources in education has not stopped growing and envisioning a future that is not only promising but even unthinkable without their use [1], doubts about the capacity to improve learning have not stopped accumulating [15].

Specifically in the area of the IDW, Barrantes Mestas [16] lists some of the disadvantages associated with its use, such as inappropriate practices, inadequate digital information selection, logistical problems, maintenance problems, etc.

Ambivalence in the use of technologies is a reality that has been evident in studies over the last few years. In 2002, the US government published a study in which no significant differences were found in tests of mathematical and social knowledge in groups using the Internet as a methodological basis and other traditional ones [17]. However, while current research findings affirm that ICT skills are related to academic success and affect learning differently [18], they depend on how pedagogical approaches consider their use and training [19].

In spite of all this, the consideration of the learning process as something very complex leads us to contemplate multiple aspects, some of which have been described as disadvantages or inconveniences in relation to the inclusion of ICT within educational spaces. Among them are the teachers' lack of knowledge of the pedagogical bases of the use of ICT or the exclusive use of the computer to the detriment of other instrumental and methodological options.

In the case of the IDW, the advantages of its use have also been studied, and there is abundant literature on its positive effects on the teaching–learning process, students and teachers [3,16,20,21].

However, the potential benefits depend on the use of the IDW, a key aspect for research [16], i.e., interaction with students may be affected, so that they do not really play an active role in their learning, but are merely passive recipients of certain visual and auditory stimuli. Or, on the other hand, in the case of students with a kinesthetic learning style (those who perceive information better when they make movements and their emotions are activated), the use of the IDW would not improve the learning processes and would minimize the didactic possibilities of its use [22].

In this sense, the IDW has, as well as some studied disadvantages, advantages that should not be seen only in the visual and auditory field. Among them would be those related to the educational relationship between teachers and students. In other words, the pedagogical use of this tool produces a positive impact on teacher–student interaction, as well as an impact on the different forms of memory. Each time teachers run software through the IDW, the potential teaching functionality is expanded, and the exploitation of resources is maximized [3].

Not only are perceptive learning styles are favored, but coding processes, memory retention and metacognitive processes are also preferred. In this way, students retain the fruit of classroom interactions more easily, due to the fact that the different memory channels (semantic, procedural, emotional, episodic and automatic) can be processed [23,24].

As far as coding is concerned, which Schacter [25] (p. 69) defines as "the processing of transformation into memory that people see, hear, think or feel", the more elaborate such processing is, the better it will leave a trace of memory in the learner [26].

This is why, in particular in the case of the IDW and other future possibilities offered by research, such as the use of "near field communications" within the framework of the "smart classroom" [27], they not only contribute to an improvement in motivation, but also more efficient learning [2].

2.2. The IDW in Language Teaching

In the case of language teaching, the inclusion of ICT in educational institutions has shown, according to studies [28], that they can improve the results of teaching and learning processes. Thus, it is suggested that the use of educational technology allows for greater effectiveness in the methods of teaching and learning foreign languages.

These technologies offer many possibilities. One of them is related to IDW. These are tools that provide added value for the improvement of teaching and learning processes [3,20]. Specifically, in language teaching, they generate an active and interactive process that has been studied since their introduction in schools [29]. With the use of the Internet, the IDW accesses multiple pages for free, which allows teachers to approach a new language in a more dynamic and attractive way, and in a more playful and interactive way [14,30].

For Dudáková [31], IDWs are related to the possibility of understanding concepts and developing certain skills. In the case of the teaching–learning of languages, they allow for an adequate understanding of information and the creative practice of the necessary skills of language learning.

The evaluation of this tool is related to the use of the IDW and, on the other hand, to the fact that students strive to work on the tasks assigned in a motivated manner [32]. Moreover, this issue usually reinforces their self-esteem and positive attitude towards the subject [33], beyond the 'novelty effect' that these same authors described. This situation, on the other hand, allows the students who use the IDW to make use of it by demonstrating their use skills in front of their classmates [34].

2.3. The IDW through Action Manager

Action Manager, a type of software in which students participate to obtain the highest possible score, is a card game where the players have to discover two equal pairs. During the game, students, individually, or in groups, take turns picking cards until they find two of a kind. When two of the same are found, an animation is started, explaining the meaning of the text inserted in the card.

Then, the students must perform the same action as the one represented through an animation and say the word imitating the intonation heard. The pair of cards that has coincided will disappear from the screen, thus continuing with the same dynamic until the completion of a total of eight pairs of cards. In the same way, students will be able to check their score. Among students, this application allows the formation of six groups of participants.

This application has a character that connects with the participants from the beginning, a nice anti-hero character who is present in six of the nine screens of the application. The three remaining screens act in a similar way, although with real people appearing in videos and photos.

Although the software offers three levels of play (elementary, intermediate, advanced), depending on the competence of the players, it is aimed at all participants because, by presenting isolated words, even players with a more elementary level can participate. Its playful character, however, allows the game to be played optimally among participants of primary level or groups of adults where the classroom dynamic is conducive.

All the linguistic components ready to be learned belong to the subject of classroom language. This includes vocabulary about actions, sounds, gestures, postures, commands, objects and feelings that happen or can be used in the classroom. Therefore, one of the objectives of this application is to facilitate the use of classroom language as part of real classroom communication to students and teachers.

In relation to the use of classroom language, experts such as Cameron [35] or Pinter [36] recommend using the target language as much as possible. However, for communication to take place in the second language, it is not enough for the teachers to speak the language, since this benefits the students' listening skills fundamentally; they must also build up the knowledge and develop the appropriate skills to do so [37], i.e., carry out activities in the classroom in which the students can learn the linguistic elements in order to use them later in a given foreign language.

It is in this sense that the AM application enables students to know the vocabulary and thus use it in a meaningful way. For this purpose, the AM application has a total of 72 words, of which 56 are verbs, eight nouns and eight adjectives.

2.4. Memory, Its Channels and the AM Application

Over the years, many ways of understanding a complex process called memory have been proposed [38]. This is a complex issue for neuroscience because the models proposed usually have difficulties in connecting the complex processes involved in them [39,40]. In addition, memory is a sensitive process that depends on the type of task to which it is subjected, as stated by Brewer and Gimbel [41].

For Álvarez [42], memory is the cognitive process that makes it possible to record, consolidate, encode, store, retrieve and access information. Fuster [43], on the other hand, considers that memory is the result of the interconnection of networks from birth, which are transformed through a complex process of synaptic associations from the motor and sensory areas to the association cortexes. Linked to this process appears another called cognitive economy, which indicates that everything that is not used is erased [44].

Portellano and García [45] and, before that, Soprano and Narbona [46], despite the controversies on this subject, where types and even meanings are discussed, describe different types of memory: sensory memory (visual or iconic and echoic), short-term memory and long-term memory (declarative, procedural/implicit, episodic, semantic, retrospective/prospective).

Sprenger [46] explains that people remember what they have learned using five memory channels, placed in different parts of the brain with different cognitive processes. These channels are semantic, episodic, procedural, automatic and emotional.

Furthermore, García-Allen [47] distinguishes between various types of memory: on the one hand, sensory memory, short-term memory and long-term memory. The latter has the capacity to store memories over a long period of time and is divided into implicit and explicit memory. It is within the latter that we find episodic memory and the semantic memory; both are closely linked to the subject we are dealing with, the latter especially to foreign language learning.

2.5. Semantic Memory

Semantic Memory (SM) contains all the knowledge a person has about the world around them, including concepts, vocabulary, rules and the correct use of these [48]. This is processed through the hippocampus in the form of a catalogue of semantic categories, which explains why learning vocabulary, especially when learning a language, is more effective when it is organized by topic or semantic categories, as Sylwester [49] points out. Therefore, the acquisition of vocabulary is optimal when the student has the option of relating a word to others in the same semantic field.

In the configuration of the AM application, the linguistic elements that appear in it belong to a related semantic field: gestures, sounds, postures, actions, orders and objects that usually occur in a classroom context. As they are habitual actions, the possibilities of repetition in the use of this vocabulary are guaranteed, thus reinforcing the memory. In relation to this, Rundu [50] conducted research on a free memory task and discovered that the more frequently an item was repeated, the better the memory of it, something that current research on the meaning of repetition confirms [51].

However, research has also warned about the types of repetition, understanding that not all of them reinforce memory. As Baddeley [26] (p. 129) points out, "pure automatic repetition is not the best way to assimilate new information". This is a common error when repetition is considered to be synonymous with memorization, not being the same thing. The type of repetition that benefits the acquisition of a word in the memory is the one in which the person elaborates connections of meanings in the semantic category and in previous knowledge of the concept [52], considering that the memory strategies are not only those that have to do with essays/repetition, but also with organization and the metacognition [53].

This is the reason why the capacity of the SM to remember depends fundamentally on processing levels (or codification), and not on structures or stores, as already expressed by Craik and Lockhart [54]. In other words, the SM is in charge of evoking concepts, symbols and words, so it becomes the necessary one to be able to speak the language [55]. In this way, when the codification of an item is elaborated,

that is, an information is rich in its perception, processing and production, the memory of it is better. In other words, traces derived from deeper complex semantic analysis are better memorized [56].

For Schacter [25] (p. 71), "only a certain type of semantic coding causes a memory depth activation". Thus, the task of orienting and controlling coding processes in such a way that students perform certain types of mental operations arises.

2.6. The Episodic Memory

Episodic Memory (EM) also plays an important role in the learning process through AM. It is in charge of storing the events and concrete facts lived throughout life, being able to recover moments through contextual information linked to the spatial and temporal variables related to such events [57]. With EM, we remember specific personal experiences.

In humans, EM is believed to be intrinsically linked to other important mental capacities such as language, sense of self and empathy [58].

This form of memory is based on the so-called Episodic-Type Memory, which, according to studies [59] we share with animals (mammals and birds), and the change to supportive EM probably occurred when the hippocampus, a homologous structure in the species, began to receive highly processed events and contextual information from the main areas of association [60].

This type of memory is responsible for memories based on images or lived episodes, so the brain evokes the memory in the form of a photo or film. That is, "episodic memories consist of representations of multiple characteristics in which many different types of information (spatial, temporal, contextual, etc.) are linked to individual awareness of personal experiences in subjective time" [61] (p. 28).

According to Strempler-Rubio, Alvarado and Vila [62], EM develops late and deteriorates early, being more vulnerable to neuronal dysfunction than other memory systems. In addition, existing studies on EM refer to the imprecision of this type of memory [63]. This is due to the fact that the person reconstructs images and facts in a subjective way, and the reconstructed version can vary from the original. However, this fact does not adversely affect the memory process in the AM application, since it is intended that the episodic imprint created in the brain helps the semantic memory of concepts, and not that the AM itself is evocative of those concepts.

2.7. The Procedural Report

Procedural Memory (PM), also called muscle memory, is activated to recall issues related to movement sequences. The repetition of movement sequences reinforces this memory, fixing it when these movements become routine [61].

It is an unconscious memory, which includes habits, awareness and classic conditioning, as well as perceptual and motor skills [64].

It is generally a faithful, rigid and lasting memory, which is gradually acquired and perfected with practice. An exception, however, are memories of situations with high emotional content, which can be acquired and formed very quickly with only one experience and maintained for the rest of one's life [65].

In this sense, the use of AM can promote PM. In fact, of the 72 concepts to be learned, 56 are actions that force students to imitate movements and make a dramatic sound. For example, when students get the "stretch" pair, they must stretch, make their own sound (onomatopoeia) and then pronounce the word.

2.8. The Automatic Memory

Automatic Memory (AM), or conditioned response memory [24], is activated by the instantaneous evoking of memories by means of a stimulus (image, music, mime, etc.). In relation to this, the final objective is that the student can freely or automatically reproduce the concepts learned. For example, when a certain event in class makes you laugh, you instantly think of the term "smile". The greater

the repetition of these concepts, the greater the neuronal connections and, with this, the greater the evocation of automatic memory.

2.9. Emotional Memory

The last type of memory cited by Sprenger [47] is Emotional Memory (EmM), which, according to LeDoux [66], has more recall power than the other types of memory.

In regulated educational spaces, EmM is activated when students participate in fun activities or enjoy a relaxed and safe environment. This is because emotional events are evoked to a greater extent and in more detail than those that are presented as neutral. For example, music can contribute to the consolidation of the memory of emotional events, in its case strengthening or deteriorating memories [67].

The AM application pursues precisely this through its dynamic and fun methodology, following the criteria of Mavrou and Bustos-López [68]. A latent danger, however, is the formation of groups in a competitive climate, which can lead to a stressful experience. It is therefore the task of teachers to facilitate a climate that seeks a balance between competition and excessive relaxation, because, as Rubio [69] asserts, a moderate level of anxiety contributes to learning success. In this respect, AM offers teachers the possibility of forming between one and six groups, which allows them to choose to form a single group in contexts where there may be too much rivalry.

Thus, EmM, as well as the other four types of memory, has its own channels of information extraction, and the ability to remember is greatly influenced by the way in which the information is exposed to a person. It is therefore necessary to consider consistency between information channels and assessment channels [47].

2.10. Audio and Visual Memory

In relation to Auditory Memory (AM), Baddeley [26] (p. 34), argues that "the underlying auditory memory system has evolved to detect and use the rhythmic and prosodic aspects of spoken language". In order to achieve a greater possibility of auditory memory with the use of AM, students listen with each animation to voices and sounds characterized by rhythmic and prosodic variability. In the same way, these voices and sounds also appear in a semantic relationship with the concrete action, so that, for example, the word "scream" begins with a shout and is then pronounced by shouting. This happens in all animations.

In the first use of AM, the auditory memory comes into play through Working Memory (WM), by means of the phonological loop. The latter is a part of the working memory "to which we usually resort when we need to retain in our minds a small amount of linguistic information for several seconds" [25] (p. 69). WM, also known as Operational Memory (OM), is considered the set of processes that allow us to temporarily store and manipulate information for complex cognitive tasks such as language comprehension, reading, mathematical skills, learning or reasoning. It is a short-term memory [70].

As AM is a recurrent activity, in which linguistic elements can be repeated several times, coding processes are repeated, and thus these elements are better assimilated. Ortega Loubon and Franco [71] explain why recurrent activity and repetition are important:

"The repeated experience consolidates the memory turning the short term form into the long term form. As mentioned, a single application of serotonin to the sensitive neurons in Aplysia causes short-term sensitization. However, five applications produce long-term sensitization, lasting several days. The process by which short-term memory is converted into stable long-term memory is called consolidation" [72] (p. 4).

Visual or Iconic Memory (VM), on the other hand, allows us to remember what we see, visual images of things, or their representations. Visual stimuli remain for a certain time in the subject in the form of an image. VM is therefore responsible for providing the brain with visual information. It covers everything from eye movements to what we remember from several years ago [73].

In the words of Orrego-Cardozo and Tamayo Alzate [64] (p. 471), the visuospatial system of Working Memory "retains mental images of visual objects and the location of objects in space. The repetition of spatial and object information involves modulation of such representations in the parietal, lower temporal, extra-crossed occipital cortex and frontal and pre-motor cortex".

2.11. Memory, Motivation and the AM Application

Dzib Goodin [73] considers that the evolutionary process specifically referring to human brains and neural networks requires multiple repetitions of learning actions, which are considered responses to the environment. These repetitions generate connections in the brain in constitutive structural units, which are constituted, hence their importance as the bases for the organization of sensations, emotions, learning, memory, thought and language.

In this way, each experience becomes an element in the organizational structure of the set of events that determine the development of learning, which is considered the set of responses modeled on culture and environment [73,74].

Intrinsically related to the human person and also to the culture to which he or she belongs, motivation in learning is a fundamental issue [75].

In the classroom, this motivation is an important component since it influences behaviors, interests and attitudes [76], which directly impact the teaching–learning process.

Thus, motivation is considered a key factor that is intended to be generated by the use of AM. As it is used as an ICT format in the classroom, it makes students perceive their learning in a less routine way and with more enthusiasm, which also has a positive influence on their performance [5].

Motivation, in this sense, appears as a driver or facilitator of cognition and emotion [6]. In this, emotions play a fundamental role, as they are considered to be essential for cognition to take place [77].

Consequently, the AM application brings together the motivational ingredients that it has been provided with, without the need for teachers to look for other strategies to motivate their students during the use of AM. Thus, what influences learning is not the intention, but the mode of cognitive processing, that is, coding operations and an environment of support for autonomy, as understood by Moè, Katz and Alesi [77].

3. Materials and Methods

The research methodology used was mixed, combining qualitative aspects (qualitative evaluation) and quantitative aspects (questionnaires). Today, qualitative research is characterized by the combination of different disciplines and objects of study [78]. Thus, some authors such as Denzin and Lincoln [79] or Flick [80] state that qualitative research is inherently multi-methodological and the use of different methods for triangulation reflects the intention of the researcher to ensure the understanding of the phenomenon under study. "Objective reality is elusive; we know one thing only through its representations" [81].

Having overcome the era in which the approach from the positivist paradigm was that which conferred empirical support to social research and demonstrated, after many years of qualitative research, that this is the most basic form of social research [78,79], "now qualitative works are accepted in a broader way than before, and this has led to a growth of interest in the combination of qualitative and quantitative techniques" [80].

3.1. Objectives

The objectives of this experience were the following:

- To test the didactic functioning of AM.
- To analyze the validity of AM in terms of the following aspects: motivation and short- and long-term memory retention.

3.2. Participants

The selection of the sample was made for the sake of convenience, as the participants were readily available for test application reasons before the experience was completed. In this sense, 76 male and 82 female students (n = 158) in the sixth year of primary education, from three different educational centers in the city of Huelva (Spain), were chosen. This group was named the "innovative group".

On the other hand, information was able to be collected on 47 additional students (17 male and 30 female students), with the same characteristics, who followed a traditional language teaching–learning methodology. This group was named the "traditional group".

Additionally, stratified sampling was used. At line level, two classes were chosen randomly by using a number generator. The reason for this procedure is the possible diversification of the student body by academic level.

3.3. Procedures, Instruments for Data Collection, and Statistical Analysis

In the framework of the evaluative research, in which the objective was to gather information about an intervention, its functioning and its effects and consequences [78], a 50-min session was developed, in which the first 10 min were used to show the application and to understand the 8 actions to be learned.

Once this was accomplished, two groups were made and a game was played, which lasted 15 min. The rest of the session was dedicated to the administration and collection of the test questionnaires: a questionnaire to ascertain the motivational impressions of the students, with simple and direct language [80]. Specifically, the Extrinsic vs. Intrinsic Orientation Scale was applied [80] (adaptation to Spanish: Jiménez-Hernández and Macotela-Flores [81]). It consists of 30 items that allowed us to evaluate the degree of motivation presented by the students and two memory tests, TOMAL and CMS. Forty-five days later, the two memory tests were repeated to compare the results with the previous ones.

The traditional group followed a conventional session for 15 min where the English words for 8 actions were taught. They were evaluated on this vocabulary at the end of the session. Forty-five days later, the two memory tests were repeated to compare the results to the first evaluation. The differences between the traditional group and the innovative group were exclusively analyzed with regard to memory performance and motivation.

A statistical analysis of the data was performed with SPSS v20 for Windows, performing parametric tests due to the sample size. Moreover, a comparative analysis of frequencies was done, in order to study the modifications of the percentages of responses obtained.

4. Results

It should be considered that the use of the AM application allows the students to learn the vocabulary through gamification and, to achieve a significant amount of learning of the English language, being able to generalize their learning more effectively. AM has a total of 72 words, of which 56 are verbs, eight nouns and eight adjectives. In total, 57.4% of the students from the innovative group remembered the words included in the application after the end of the activity and, in the follow-up evaluation 45 days later, the percentage increased to 70%.

The results of the study have been divided into different areas: on the one hand, the motivational aspects and, on the other hand, the impact on memorization in relation to the learning aspects of the learning of English as a foreign language. In relation to the motivational aspects, 70.88% of the participants from the innovative group stated that they enjoyed the activity very much and 23.41% said that they enjoyed it a lot (only 5.69% stated that they did not like the activity at all), which points to a good group motivation towards the activity (Figure 1). Of the traditional group, 27.65% stated that they enjoyed the activity very much, 40.42% enjoyed a lot, 19.14% intermediately enjoyed it, 8.51% a enjoyed it little and 4.25% did not enjoy it at all.

The same percentage of innovative group (see Figure 2) indicated that they had fun with the activity carried out with AM (70.88% very much and 23.41% a lot). In total, 83% of the participants indicated that they had understood the actions to be learned (it should be remembered that the instructions were only in English for carrying out the activity), compared to 17% who did not understand them.

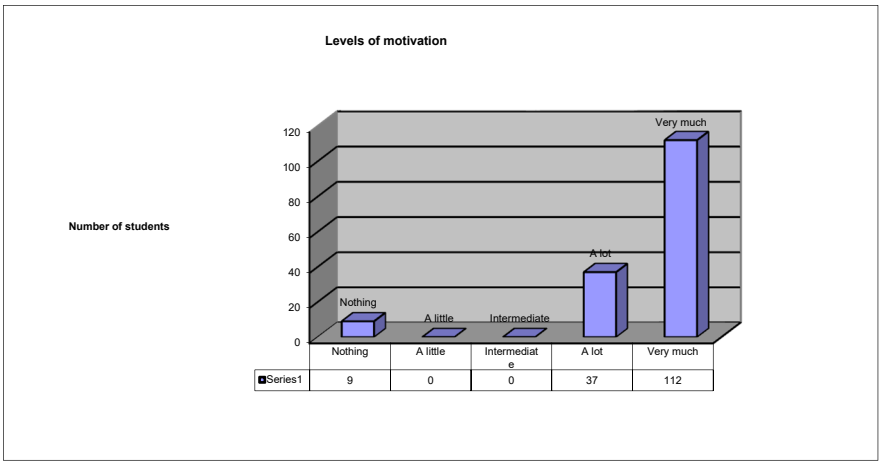

Figure 1. Levels of motivation during Action Manager (AM).

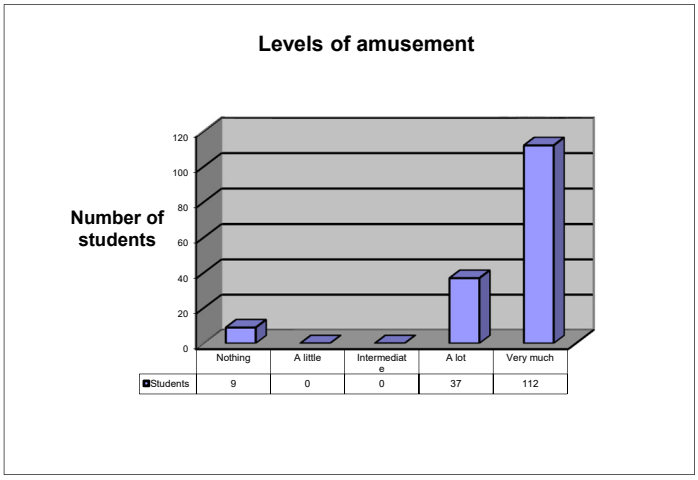

Figure 2. Levels of amusement during AM.

Furthermore, the participants were asked if they had been distracted during the performance of the task, to which 70.25% responded that they had not been distracted at all, 17.7% indicated that they had been a little and 12.02% responded that they had been quite distracted (Figure 3). With regard to emotional memory, the AM application enables fun or enjoyable activities in a relaxed and safe environment. This is achieved thanks to its dynamic and entertaining methodology. In this sense, and according to the organizational flexibility related to this application, a degree of emotional activation was made possible according to the state dependence.

With regard to the memory tests (guideline 3), the impact on memory is even greater 45 days later, as shown in Figure 4, where the scores obtained at the end of the activity, compared with the follow-up period, are improved by 20 percentage points (79.1% compared with 57.6% in the first evaluation). The test consisted of a mime where the students had to mark their written representation from a total of seven action words (hiccup, hiss, scream, yawn, stretch, snore, sigh). Four of them were selected at random, identical in the two moments of the evaluation (hiccup, hiss, yawn and stretch). Student's *t*-test was used to compare the scores obtained by the same sample at two different time

points, and statistical significance was obtained in three of them: "hiccup" (p = 0.011; SD = 0.53), "yawn" (p = 0.048; SD = 0.70) and "stretch" (p = 0.000; SD = 0.54). In the fourth case ("scream") not significant differences were obtained (p = 0.16; SD = 0.67).

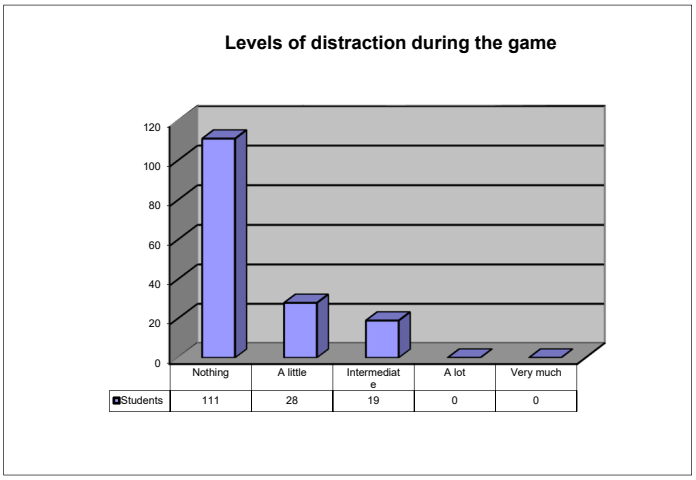

Figure 3. Levels of distraction during AM.

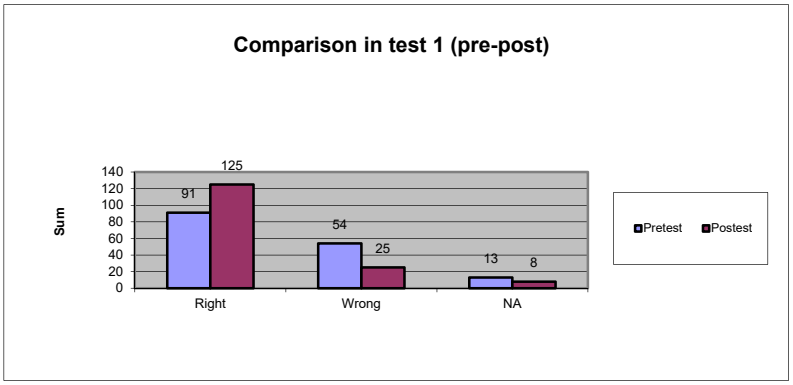

Figure 4. Comparison in test 1 (pre-post).

The results obtained with the traditional group (n = 47) were different. Under the same conditions as the innovative group, the memory points obtained at the end of the activity showed that 65.9% answered correctly, but in the follow-up evaluation the percentage dropped to 59.9%. Student's t-test, to compare the obtained scores in both moments, was used. Of the four randomly chosen words (stretch, hiss, hiccup and yawn) not one significant difference was found between the post-activity evaluation and the follow-up.

Similar results were also found in a more difficult test, where students from the innovative group had to write the corresponding word after seeing it represented visually, as shown in Figure 5. In this sense, the statistical analysis, using Student's t-test to compare the two evaluation moments, showed statistical significance in the four randomly chosen words: "sigh" (p = 0.029; SD = 0.98), "snore" (p = 0.013; SD = 1.04), "yawn" (p = 0.032; SD = 0.85) and "hiss" (p = 0.032; SD = 0.43). Visual stimuli allow the brain to provide visual information through visual memory. The repetition of these stimuli consolidates the memory of them. The AM application allowed for the improvement of memory through visual stimuli. These repetitions contributed to the improvement of memory in 68.3%, compared to 46.2% in the evaluation made immediately after the activity. In the traditional group, there were no significative statistical differences between any of the words.

In terms of the impact on procedural memory, of the 56 actions that required students to imitate movements and to make a dramatic sound, 65% of them were remembered by the participants with their actions in the post-assignment test.

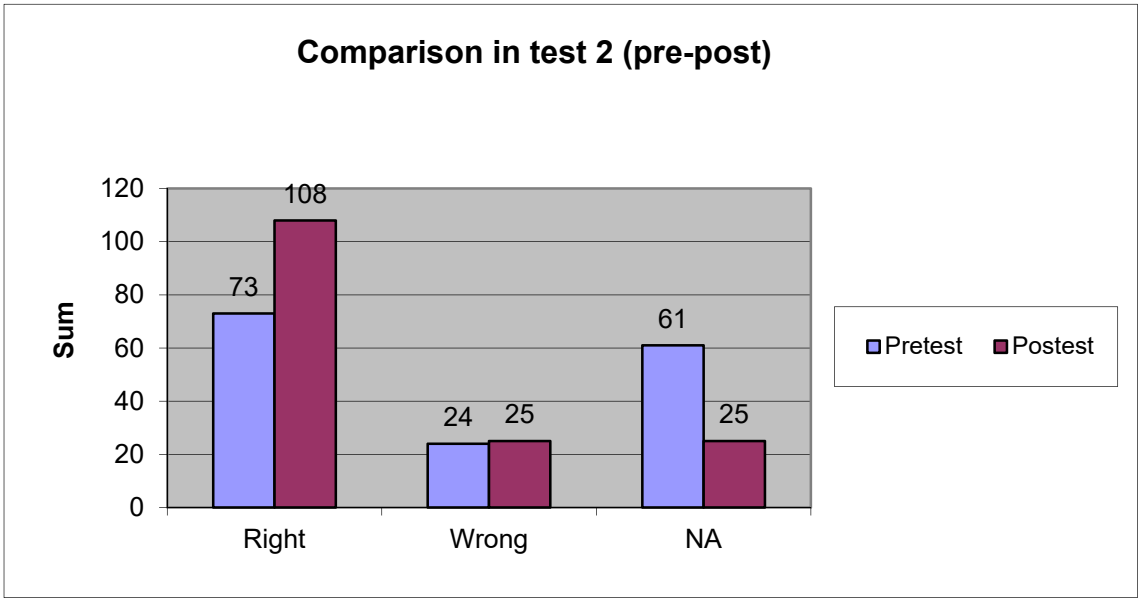

Figure 5. Comparison in test 2 (pre-post).

5. Discussion

In this research, we have delved into the development of the different types of memory and their relationships with the AM application. The intention was to offer relevant information for researchers who intend to investigate, in this or similar fields, the consequence of the increasing use of applications and software in the educational world. On the other hand, the results obtained allow us to respond to the objectives outlined.

Although we were unable to establish a comparison with a control group of identical characteristics (as this was not the main objective of this study), the maintenance effect is superior in the innovative group compared to the traditional group. This can be due to the level of motivation for the implementation of the activity presented to the traditional group. The retention and maintenance of learning seems to be more efficient with the AM than with traditional teaching methods, increasing the points in the follow-up evaluation.

The results obtained in relation to motivation and distraction are in line with the statements of Usán and Bordás [6] about facilitators of motivation and emotion and, consequently, of cognition. AM is an activity based on play through games, and play is a purposeful activity for children, around which they organize their learning and growing. A purposeful activity can be defined as a task or experience in which the person participates actively, requiring and eliciting coordination between the physical, emotional and cognitive systems of the individual. When the subject participates in a purposeful activity, they directs his attention to the resolution of the task. In this way, a purposeful activity, influenced by the vital roles of the individual, has a unique value and meaning for each person [82–86].

The differences obtained and the high scores may be due, among other aspects, to the purposeful nature of the activity, which allows the participants to focus their attention on the performance of the tasks, reducing environmental distractors and facilitating better information processing. Furthermore, having fun doing the activity with AM involves a set of neurophysiological responses related to the activation of the brain's reward system [87].

Addressing the learning of English language through play, in this case through ICT, it allows for the enhancement of the use of executive functions (such as attention, the beginning of the activity or

the maintenance of the task), precisely because of the purposeful character of the activity, in line with the works of Noroña et al. and others [87].

Regarding memory tests, the memory impact is even greater 45 days later, an aspect related to the studies by Orrego-Cardozo and Tamayo Alzate [64], Guzmán, Véliz and Reyes [56] and García-Allen [48] on the different memory channels. The use of different channels in a combined way to provide information facilitates the learning of terms in the English language, which is also related to works such as those of Talaván [88] or Wang and Shen [89].

Education during the current pandemic has been heavily influenced by e-learning and distance education [10]. Students have had to participate in the educational process under a modality in which overlapping schedules and roles or self-learning have conditioned their academic success. In many cases, they have continued applying educational methodologies of a face-to-face nature in online formats, which has made it difficult for students to acquire significant learning [75]. The results obtained with Action Manager (both at the end of the session and in the follow-up) show the effectiveness of the combination of ICT (software and hardware such as IDW) and gaming-based methodologies, and represent an opportunity for their use in online or blended learning environments.

The design of activities through Action Manager allows the application of Universal Design for Learning (UDL) criteria, which are of special interest in a post-pandemic scenario. Using UDL increases the positive perception of e-learning and also helps the learning of those who are not used to the online mode, who experience barriers, or do not have sufficient resources to cope with it [76]. This is very important in the present time, where it has been seen that the follow-up of tasks designed using e-learning during confinement has been especially difficult, precisely because there are no criteria specific to UDL, nor are there elements that would increase the extrinsic motivation of students.

6. Conclusions

This experience allows us to conclude that the inclusion of ICT, which are especially useful in language learning, should be called upon to play a fundamental and growing role in the teaching–learning processes, either in person or, predictably, after a change in the trend caused by the COVID-19 pandemic, online. These are the bases of the new educational paradigms, which are more focused on the person, where functions such as memory and processes such as motivation are very important in the consolidation of learning within the framework of the commonly named "smart classroom". The IDW has gradually become one of the most comprehensive and innovative resources for teaching, thanks to its touch interface connected to a computer. Part of its versatility is due to the possibility of bringing together other valuable components to generate dynamism in the classroom, such as software and peripheral devices, whether on site or remotely.

The AM application allows for the development of more optimal levels of motivation thanks to its characteristics, functionality and, consequently, its possibilities, which are related to a positive impact on the behavior, interests and attitudes of students, which are, in turn, fundamental for the development of teaching and learning processes in the context of foreign language teaching.

Motivation in AM is determined by several factors that facilitate its activation: the use of ICT, images and sounds that are striking or appealing, non-routine activity, competition by groups and objectives to be met (to get the greatest number of pairs).

The effectiveness of ICT, and in particular of IDW and AM, depends on the conditions and the pedagogical approach that the main actors are able to carry out. Despite this, their potential in the development of different forms of memory is significant, as has been pointed out.

Responding to the objectives set out in this research, we have verified how AM's didactic functioning is optimal, allowing students to learn new English language vocabulary in an entertaining way (gamification), making their learning more effective.

On the other hand, regarding the objectives related to the analysis of AM's effectiveness in terms of motivation and short-term and long-term memory retention, we concluded that the vast majority of participants (70.88%) enjoyed working with AM, which is a fundamental motivation for learning.

This is also related to the low distraction of the participants during the AM activity—70.25% of the respondents said that they were not distracted at all.

Finally, in relation to memory retention, we conclude that AM contributes significantly to improving memorization, as shown by the 20-percentage point increase after 45 days. In short, we are facing the possibility of improving motivation, attention (and the avoidance of distraction) and memorization skills of students through AM (in a gamified environment) in a very important way.

The application of strategies supported by ICT, such as in the case of Action Manager, in which a high degree of involvement by students (who participate in the activity from the perspective of play) has been detected, and seems to favor language learning. This fact can be generalized to education at home, as a consequence of the confinement derived from COVID-19, since it also incorporates elements of the Universal Design for Learning. The principles of the Universal Design for Instruction are also easily applicable, allowing for the special educational needs of students, including those derived from a disability.

The latter elements are among of the keys to achieving the objectives of Agenda 2030, in line with the Sustainable Development Goals. They make it possible to attend to human development and provide an education that is both inclusive and of high quality. It cannot be forgotten that sustainability, and particularly sustainable development, following the United Nations, depends to a great extent on education and that the objectives of development cannot be achieved without it.

At a time of international crisis such as the COVID-19 pandemic, with a great impact on access to the educational system for millions of schoolchildren, the use of tools such as the one analyzed in this article (which demonstrate the acquisition of learning from the perspective of neuro-education) is essential in post-pandemic society, not only for the strength of learning (as has been seen in the follow-up analysis of the participants), but also for assuming a work model that deepens in the equity and in the equality of opportunities for access to education.

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