MOW: Augmented Reality Game to Learn Words in Different Languages

Case study: learning english names of animals in elementary school

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Abstract— **Recent digital games have been developed not only for entertainment purposes, but also to promote learning. This paper presents MOW (Matching Objects and Words), which is an Augmented Reality (AR) game for learning words in different languages. Experimental tests were performed with Portuguese children during English classes. We have compared the results from using MOW along with traditional teaching methods. The results indicate that children who used the Augmented Reality games had a superior learning progress than those who used only traditional methods.**

Keywords-component; Augmented Reality; educational games; learning words

I. INTRODUCTION

Nowadays, the use of digital games is commonly accepted as a powerful tool in the teaching and learning process. Games can be successfully used to address different types of learning as well as a variety of subjects. E.g. Mayo et al. [1] describe games to teach science and engineering better than lectures. To teach physics, Squire et al. [2] also reveals that games are superior than lectures and Coller and Scott show that students using video games are more engaged [3] and learn more than with a traditional textbook [4]. These games fundamentally exploit the potential of the computer. However, there are other types of technology whose specific features provide a great advantage, namely by using larger realism and natural interactions.

Augmented Reality (AR) can be used to bring virtual elements into the user space, providing a natural and pleasant experience with the new environment. Here, computer combines virtual information – visual or other – with reality, showing the user a single mixed environment [5]. By using the hands, in an AR application, the users are provided with a more natural human-computer interaction, since it brings the user space virtual objects, allowing him to handle both real and virtual objects in the mixed environment without the need of special equipment such as joystick, keyboard and mouse [6].

Many AR applications have been developed in several and different areas of human activity, such as: entertainment [7]; medicine [8]; education [9] [10]; and commerce [11]. However, there are limited solutions and studies regarding the applications of AR for the very specific public of young children (5-12 years old) [12]. Besides, the majority of these studies results are only thought of to promote motivation and engagement. E.g. in [13] and [14] a post-game questionnaire is applied to show that children preferred the AR rather than the real.

In this paper, we present an AR game (MOW – Matching Objects and Words) that allows children to learn a variety of words in different languages. We evaluated the MOW game during the English classes according to the very common didactic and pedagogical aspects. Consequently, the children are assessed by their teacher by using traditional and conventional assessment methods, corresponding to the very teaching approach focused on the real obtained knowledge regarding the concepts that were taught by using both the AR games and the traditional methods or materials.

This paper is organized as follows: the next section describes related work on educational games with AR; section III describes the design and implementation of the MOW game; section IV describes experimental tests performed with children in English classes; and section V concludes the paper.

II. RELATED WORK

There are numerous areas where AR can be applied, ranging from entertainment to other areas and its most serious domains. When it comes to the educational area, in [13], an AR game has been thought of and developed to help children developing their skills in a more motivated way. Therefore, in this game, the child is required to correctly spell words by placing and aligning the markers representing each alphabet in their correct positions. Children played the AR game and the equivalent real game. When comparing the results of the two games presented, they did not found significant differences between the two games except for one question: 81% of the children preferred the AR game. Similar to [13], in [14], an AR game that uses pre-defined markers has been developed to educate children on endangered animals. Again, their study shows that children preferred playing the AR version of this game rather than the real version.

To support the teaching of music, an AR game has been developed in [15], where known symbols are added in the form of virtual objects to the real environment, helping people with learning disabilities to visually understand the concepts. It uses pre-defined markers and a camera mounted on a personal

computer. Each marker represents a certain musical note and they can be placed according to what the therapist intends to teach.

Another relevant work has been developed in [16] to assist cognitive disabled children in decision making process. This game consists of a book with several sorts of virtual markers, each of them representing a different type of vegetable. The goal of the game was to match vegetable entities according to their functions shown on a reference page. Their research showed that cognitive disabled children in the AR conditions were more motivated to complete the tasks than other children on the control condition.

Finally, in [12], a study has been conducted to compare the use of AR with traditional teaching methods to teach 10 year old students. Their analysis of the teacher-child dialogue revealed that children using AR were less engaged than those using traditional resources. On the other hand, Freitas and Campos [17] conducted a study on the design and evaluation of AR for teaching 2nd grade-level concepts. Their results indicated that AR helps increasing motivation among students, therefore contributing positively on the learning experiences, especially among students with more difficulties, showing some contradiction with the results presented in [12].

III. Design and Implementation

MOW (Matching Objects and Words) is an educational AR game developed in collaboration with elementary teachers that allows children to learn a variety of words in both Portuguese and English languages, through a very first visual contact and oral comprehension, followed by an ongoing recognition and verbal domain of written words, much supported by memory as it is exercised through specific tasks within the game, providing to young children a full training and exploration of their inner abilities and learning capabilities. Consequently, the MOW game involves a matching task and provides visual and auditory cues to help children pronounce and write words.

Figure 1. Examples of template-based markers used in MOW.

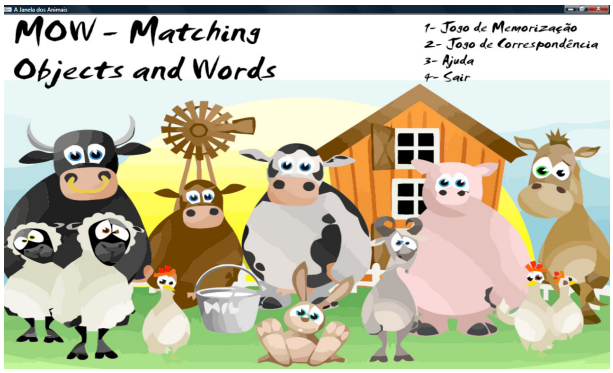

Figure 2. MOW start menu.

As most AR games [18], MOW uses a marker-based technique to accurately determine the position and orientation when it comes to place virtual objects in the real world. Hence, for this, we have used the ARToolKit [19] and the OpenCV library for tracking and registration. To capture the real world we used a USB video camera (Logitech C600) and the virtual models that appeared over the markers were created in the .wrl format and loaded and displayed using the OpenVRML library.

In the case study presented in this paper, the virtual objects that appeared over the markers are animals. These animals were chosen in collaboration with teachers taking into account the unit plan taken from the syllabus where they are object of study in their elementary school. Each of these animals' models is associated with a particular AR marker. Inside the markers there are drawings of animals that correspond to symbols that will be identified by the system. As these drawings are common, children can easily identify the virtual model of the animal that they wish to see in AR. Fig. 1 show some template-based markers used in MOW.

MOW is composed by two different games that can be selected when the applications starts. Fig. 2 shows the start menu of MOW. Game 1 ("1- jogo de memorização") is a memory game, through which children can learn the names of animals in different languages. Game 2 ("2- jogo de correspondência") is a matching game, through which children can practice their skills. Option 3 ("ajuda") is the help menu, which contains instructions about how to use the AR games. When the games starts, there is also a button "1-help" that allows to see instructions about how to play the games and a button "2-back" which allows going back, if possible, to the main initial menu.

The basics steps in the game 1 are as follows: when a child/pupil places a marker with a drawing of an animal (first three rows of Fig. 1) on the top of the game board view by the camera, the visible marker is recognized and the virtual model of the animal is overlaid in the position and orientation of this marker. After that, depending on the next marker detected in the image, a specific action will be performed. For this, we also use in MOW what we call dynamic markers. These template-based markers are responsible for determining the type of action that will be executed, contextualizing the user´s request, and the symbols in these markers are, respectively, the flag of the United Kingdom and the flag of Portugal (fifth row of Fig.

1). Thus, for example, when a marker of an animal is recognized in the image, simultaneously with the United Kingdom marker, the corresponding actions are identified with the following: a sound pronouncing in English the name of the animal seen at the visual scene is played and on the screen a subtitle with the name of the corresponding animal is displayed. If the dynamic marker is the Portuguese flag, the game will run in the very same way but the sounds and the subtitles will be in Portuguese.

The insertion of a sound is related to playing an audio file when the virtual object and a dynamic marker are placed over the game board. The sounds played in MOW were recorded by using Audacity [20] and saved as mp3 files. Each time the marker enters the scene with a dynamic marker, the virtual object is placed over the marker and the sound is played. If one marker is taken back and the sound is still playing, it is interrupted. The disadvantage of the use of sounds is that, if the available audio hardware has poor quality and limited resources, the reproduced sound can be completely different from the original.

Fig. 3 shows a flowchart that represents how the game 1 works. The main goal of this game is to encourage children to memorize how to write and pronounce the names of animals in Portuguese or in English. In this sense, the game ended only when all virtual objects were displayed and child see and hear at least one time the English or Portuguese name of the animal.

Regarding to game 2, the user is asked to create a match between the animal (the marker with the drawing of the animal) and its corresponding English name (the marker with the written name of the animal). In this game the markers and virtual models used are the same as the ones used in the game 1 except for the fact that, in this case, we have replaced the dynamic markers (the flags) by new ones with the written name of the animal (examples of these markers are in the fourth row of Fig. 1).

When playing the game 2 the 3D model of the animal will only be overlaid over the marker with the written word of the animal when a correct match is found (a marker with the drawing of an animal and a marker with the written word of the animal are placed and recognized in the game board simultaneously). E.g. the marker with the drawing of a "bee" corresponds to the marker with the written word. If this match is incorrect an audio file ("wrong answer") is played, a subtitle "wrong answer" is rendered over the game board, and the game counts as a wrong attempt for this player. In the case of several dynamic markers are recognized simultaneously, the answer is not valid and none virtual model of the animal will appear superimposed on the image of the real world.

The game ends and shows the player scores when the child succeeds in choosing the correct match between all animals and their corresponding English name. The student who can perform all the matches between each animal and their names in English with the lowest number of incorrect attempts is considered the winner. This application shares the same concept as traditional matching games, but in this case the answers are immediate, thus encouraging the students to self-correction and to challenge among them. Fig. 4 shows how game 2 works.

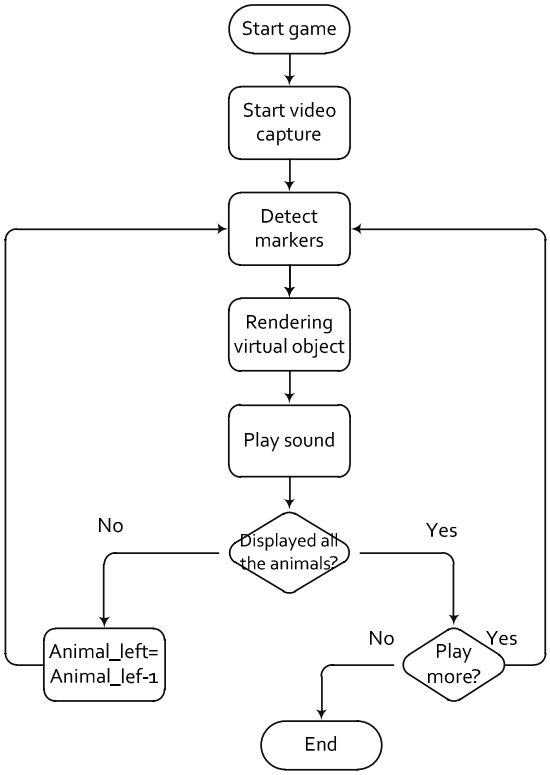

Figure 3. Flowchart of the game 1.

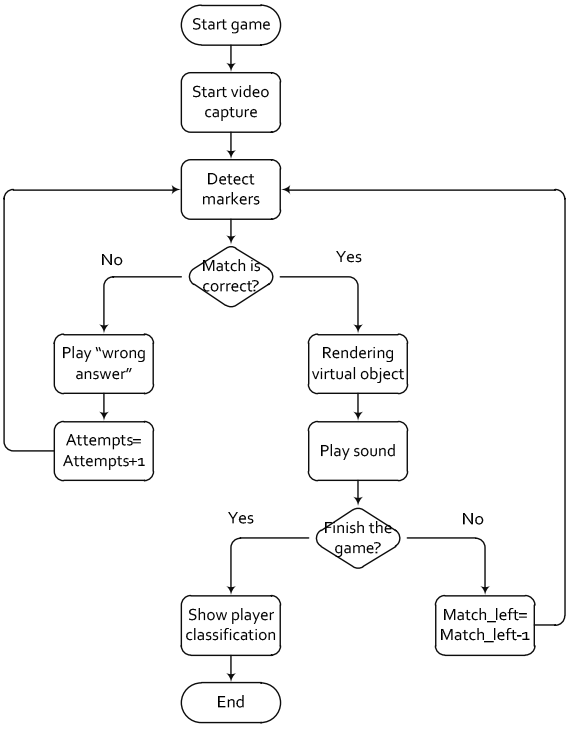

Figure 4. Flowchart of the game 2.

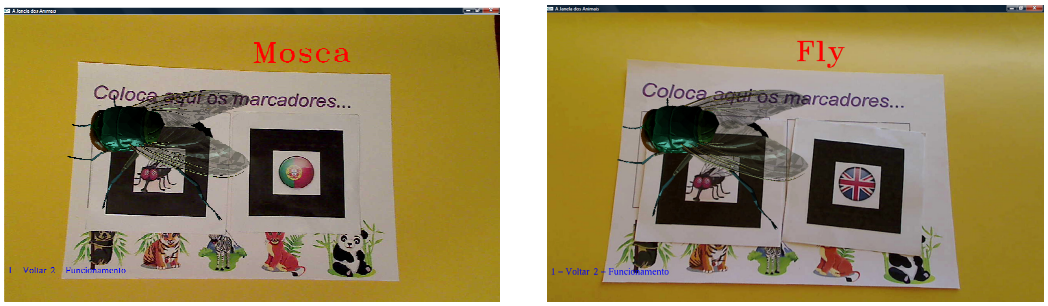

Figure 5. Game 1 being played with Portuguese (left image) and English (right image) words.

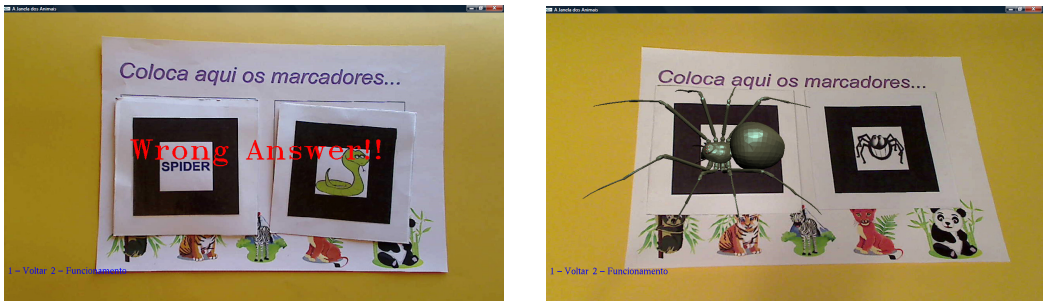

Figure 6. Game 2 being played. An incorrect match is performed on the left image and a correct match on the right image.

Fig. 5 shows an example of game 1 and Fig. 6 shows an example of game 2. In Fig. 5 we can see the recognition of template-based markers, the insertion of corresponding virtual model in the real world, the placement of information subtitles on the screen and the appropriate sound being played. In this case, the sound heard would be "fly".

IV. Experimental Tests and Results

In the case study presented in this paper, the experiments were conducted only with the English version of the game to study the impact of MOW in the foreign languages teaching. These experiments were conducted with twenty-six children aged from 7 to 9 years old who are attending the 3rd year English Curriculum Enrichment Activities (CEA). All the experiments with the MOW game and their evaluation were completed at an elementary school, in Portugal, whose staff expressed a great interest in taking part in assessment process. The MOW game was previously installed in the laptop available in the classroom and the teacher was consequently provided with information on how the AR games could be used. After that the teacher uses it in his classes as a supporting tool in the same way as traditional materials.

A. *Procedure*

To compare the impact of using MOW with the traditional teaching method, children were split into two distinct classes of thirteen students:

- Group 1 – Children who used the AR games during the English classes.
- Group 2 – Children who only used traditional teaching methods during the English classes.

The students were choose considering than, accordingly to the school teachers', they belonged to similar sociological and pedagogical quadrant. Initially, a lesson was prepared by the teacher with the purpose to theoretically teach how to write and pronounce the name of the animals in English language. The class was given to both groups and had duration of approximately 45 minutes. This class had an exercise where the students had to write on the white board. The AR game validation process has occurred in a second class and had the duration of approximately 90 minute. It occurred as follows:

- Group 1 played MOW (both game 1 and game 2) as a memory exercise and self-study promotion.
- Group 2 performed memory exercises based only on traditional teaching methods (included images, pictures and flashcards), and as exercise for self-study promotion was made a match exercise in paper.

In both groups, classes were taught by the same teacher and the exercises were made by a couple of students by alphabetical order. During the experiments the two groups of children had no direct contact between them. In the case of students, who played with the AR games, all the instructions were given by the teacher, so that students themselves could appropriately play against each other. During the classes, children could also make questions to the teacher and express themselves.

Fig. 7 shows children playing with MOW in the English class. The experimental set-up used a laptop equipped with a webcam. Each child sat in front of a table where the game board interface was presented. The webcam was placed vertically on the top of the laptop. While the child handled the patterns, he/she looked at the AR scene in front of him.

Figure 7. Children playing with MOW during the English class.

B. *Results and Discussion*

In order to determine the initial level of students' knowledge about animals corresponding to the unit lesson that would be taught in English CEA, a diagnostic test was made and corrected by the teacher a week before the experiments were started. This writing test aim was to verify the initial knowledge that students already had and compare it with a formative test done in the next week after the experiments be realized. Comparing these two tests we could evaluate the children English learning progress.

It is emphasized that both tests were the same for the two groups, although their elaboration and conception were done by both groups of teachers, according to the teaching School Program. The assessment patterns were also established by the responsible teacher.

Tables I and table II indicate the results between the diagnostic test and the formative one of both groups.

TABLE I. CHILDREN WHO USED THE AR GAMES

	Diagnostic test	Formative test	Individual progress
Student 1	12%	76%	64%
Student 2	47%	65%	18%
Student 3	41%	77%	36%
Student 4	47%	78%	31%
Student 5	12%	79%	67%
Student 6	41%	97%	56%
Student 7	58%	100%	42%
Student 8	29%	68%	39%
Student 9	24%	44%	20%
Student 10	76%	100%	24%
Student 11	47%	82%	35%
Student 12	47%	74%	27%
Student 13	12%	68%	56%
			Class progress = 40%

TABLE II. CHILDREN WHO DID NOT USED THE AR GAMES

	Diagnostic test	Formative test	Individual progress
Student 1	17%	39%	22%
Student 2	0%	21%	21%
Student 3	47%	68%	21%
Student 4	0%	29%	29%
Student 5	12%	62%	50%
Student 6	10%	56%	46%
Student 7	35%	62%	27%
Student 8	29%	82%	23%
Student 9	53%	92%	39%
Student 10	88%	97%	9%
Student 11	59%	94%	35%
Student 12	59%	100%	41%
Student 13	70%	88%	18%
			Class progress = 29%

Analyzing the results of the mentioned diagnostic tests, we can verify that both groups of learners had a similar initial expertise. Group 1 students obtained the average classification of 40% and group 2 obtained the classification of 37%. The most important facts that can be observed in tables I and II are the values related to the children progress. These values are calculated as the difference between the percentage values that the same group of children had in the formative test and the diagnostic one, thus measuring the learning progress. It appears that the first group of students, who used the AR games, had improved the classification by 40% when compared to the initial learning level. The second group of students (who used only the traditional methods), obtained an improvement in the classification of 29%.

Therefore, these results indicates that children from elementary school who used MOW games had a superior English learning progress, verified by the difference between the diagnostic test and the formative one of about 11%, compared with the group of students who only used traditional methods. A possible explanation for this is due to the fact that AR provide to the children a good and very motivating ([14] [15]) learning experience to improve all their abilities, thereby maximizing the children interest towards the subject of study.

Regarding the observed behavior of the children in class during the AR experiments, they had no difficulty in using the MOW game and had a well interaction with the tray of games and the respective markers. The fact that the markers move freely through space game appealed the children attention, because it's a natural movement and through it the markers and the consequent virtual objects will be placed over it. Most of the children commented that markers were magic.

Finally, the children were asked to fill in a short post-game questionnaire in the five-point Likert scales for answering a question that aimed at determining how easy it was to interact with MOW. As possible answers to the following question: "*Using the games during the classes was?*" there were the following: very difficult; difficult; more or less; easy; and very easy. Fig. 8 shows the results of this question.

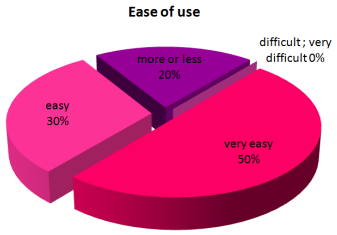

Figure 8. Children's answer when asked about the easy of use of MOWs.

V. CONCLUSIONS

We have presented an AR game (MOW) thought of to the learning of both Portuguese and English languages, focused on specific words, in a simple, interesting and interactive way. MOW involves a matching game and provides visual and auditory cues to help children learning how to pronounce and to write animals names. Twenty-six children from a Portuguese elementary school participated in an experimental test. We have compared the results as obtained from the very use of MOW with those resulting from the more traditional methods conventionally used to learn English in the CEA classes.

The results indicate that children who used the AR game had a superior English learning progress than those who only used traditional methods. Furthermore, the children considered the AR games easy to use. Thus, our work indicates, that the use of AR games has a positive pedagogical impact in the learning process concerning young children, more exactly in the progressive domain of oral recognition of words and concepts and their corresponding written form. Accordingly, we strongly believe that AR will be, in a short term, an important tool in the class activities in some areas of education. The statistical relevance of the results were tested, however due to the small size of the sample (only 13 participants en each group) these results were inconclusive. Thus, a more exhaustive evaluation based on a bigger sample could be performed.

Also interesting is the fact that this game provides the teachers a didactic material which may overcome the many difficulties resulting from the unsuccessful efforts sometimes made when it comes to the teaching processes concerning the different linguistic topics. Furthermore, because of the language related training allowed, namely the strengthening of the lexical domain (the written form of words, and its oral production), the child may be able to progressively acquire a progressive capacity for the future deciphering activities as a part of their evolution on reading matters [21].

As a future work, the MOW game can be well extended to the teaching and learning processes with students of other ages and in the teaching of other languages. Since MOW runs in a simple and cheap hardware that requires only a PC equipped with a webcam, it can be used for teaching aids in most schools.

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