IdeAR: Augmented Reality Applied to Reading Comprehension Stories

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***Abstract*—A problem in many schools is the difficulty of students to understand texts, which is due to multiple factors, including habits and motivation to read. On the other hand, augmented reality is a didactic technology which, when applied to the educational area, becomes a dynamic, interactive activity and arouses interest in the student. This study shows the results obtained after the application of augmented reality for reading comprehension through stories in fourth grade primary students. A mobile application based on augmented reality named "IdeAR" was implemented using Mobile-D methodology. For empirical demonstration the statistical sample included two sections of students from a public school in Lima city, where the experimental group showed improvements in memory level and content understanding. Finally, this work is important for the educational sector because it provides a tool that favors teaching with a STEAM approach.**

***Keywords*— augmented reality, reading comprehension.**

I. INTRODUCTION

Reading comprehension is an important human activity for acquiring knowledge, since it exercises the mind and develops concentration, observation and reflection; likewise, its exercise "is a daily and imperative practice in the contemporary world" [1]. While reading is a fundamental instrument for cognitive and intellectual development, its main benefit is the enrichment of vocabulary; in other words, learning new words, which allows us to express our ideas and opinions in a better way. Is also known that first-world countries have high levels of reading, habit that is instilled in children from a very early age. On the other hand, is not new that a large population percentage does not have reading habits and shows difficulties in concentrating and understanding text; which will then affect not only their academic life, but also their professional life.

The literature describes reading comprehension as a process where the reader constructs a mental representation of the information contained in a text. It involves a set of strategies for its understanding, requiring an integration between this decoded information and previous knowledge, as well as the specific sociocultural context of the reader [2].

Snow [3] argues that understanding involves three elements: (1) The reader who performs the act of reading and requires cognitive abilities (attention, memory, critical and analytical capacity, and inference), motivation, knowledge (vocabulary, subject knowledge, knowledge of comprehension strategies), to which previous experiences are added. (2) The text, whose characteristics influence understanding. While reading, the reader constructs several text representations important for understanding, those representations include the exact wording of the text, the text base (units of ideas representing the meaning of the text) and mental models (the way information is processed to get its meaning). Digital text presents particular challenges to understanding, but it also offers the potential to support understanding by providing hyperlinks to difficult word definitions or other material. (3) The activity, which has to do with the purpose for which the reading is performed within a specific context. The initial purpose of the activity may change as the reader reads, i.e., a reader may find information that raises new questions and make the original purpose insufficient or irrelevant. Finally, the reading results, are part of the activity and can include an increase in knowledge, a solution to some real world problem, among others.

The study by IEA about the Progress in International Reading Literacy Study-PIRLS, indicates that the international average for the 2016 cycle was 511 points, with a standard deviation of 80 points. Scores range from 581 to 320 obtained by the Russian Federation and South Africa respectively. In the region, Chile has a general reading comprehension average of 494 points, 17 points below the international average [4].

In 2016, the Student Census Evaluation (ECE) was conducted for more than 500,000 students in the second and fourth grades of public and private schools throughout Peru, it shown that more than 50 percent students have reading comprehension difficulties, results that have a slight improvement compared to previous years [5].

According to the PISA ranking 2016 [6] reading level issued by PISA tests, it placed the Spanish-speaking countries: Autonomous City of Buenos Aires (38) and country-level Chile (42), Uruguay (46), Costa Rica (51), Colombia (54), Mexico (55), Brazil (59), Peru (63), and the Dominican Republic (66). In which it is denoted that Peru is the country with the greatest growth in Reading, Science and Mathematics competencies.

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TABLE I. COMPARISON OF COUNTRIES IN READING PISA

Average		Country
2016	*2018*	
535	549	Singapur
497	505	U.S.
493	487	PISA Average
459	452	Chile
437	427	Uruguay
427	426	Costa Rica
425	412	Colombia
423	420	Mexico
407	413	Brazil
398	401	Peru

Source: PISA Reading performance

Reading Comprehension and STEAM approach

Current education has adopted the paradigm of training, to which is added superior cognitive skills in reading comprehension, as a basis for developing communication skills (oral and written) and critical thinking; fundamental to learning the other areas. [1], [7].

The learning, nowadays, is given in a context of knowledge integration, as the STEAM educational method, by its acronym in English (Science, Technology, Engineering, Arts and Mathematics), which raises educate articulating these areas of knowledge [8]. Along the same line, the OECD PISA Report measures academic performance worldwide in the areas of mathematics, science and reading.

Under the STEAM approach, reading stories is taken to another level, connecting it with mobile technology and augmented reality to recreate situations, objects, animated beings or characters. In addition, this technology considers the interaction and gamification that stimulate the student to continue reading. In this way, not only the understanding of the text is achieved, but also imagination, creativity and critical thinking are improved.

Augmented Reality

From literature, the augmented reality is defined as a technology where the perception and interaction intervene in the real world; allowing users to be in real environment, increased with the additional information generated by the computer [1], [7-9].

Augmented reality poses four levels or degrees: (A) Degree 0 linked to the physical world. Applications are linked to the physical world by the use of barcodes and 2D (for example, QR codes). These codes only serve to link to other content, so there is no 3D record or tracer. (B) Grade 1 RV with markers. Applications use black and white images, markers, quadrangular and schematic illustrations, usually for testing 2D patterns. The most advanced form of this level also allows the verification of 3D objects. (C) Grade 2 RV without markers. The applications replace markers to use GPS and the compass of mobile devices to pinpoint the location and orientation of the user, superimposing points of interest on real-world images. (D) Grade 3 Increased vision. It is applied through contact lenses that have high technology or others that, in the future, these lenses offer a completely contextualized, immersive and personal experience (e.g. Google Glass).

Mobile App

According to the Mobile Marketing Association [10], one of the fastest growing segments associated with the evolution of mobile technology can be found on most phones, even in the most basic models. (p.2). The mobile technology and augmented reality converge, allowing the real world to combine, offering a series of opportunities to take these tools to the traditional classroom.

II. DEVELOPMENT METHODOLOGY

For the implementation of the AR-based mobile application, the Mobile-D agile methodology was adopted, consisting of five phases: (1) The exploration phase, where stakeholders were defined, scope and requirements of the application. (2) The initialization phase, where the plan was prepared and the working environment configured, allocating the required hardware and software resources. (3) The production phase of the application modules to meet functional and non-functional requirements. Initial prototypes were developed, followed by the final design and implementation. (4) The stabilization phase, where functionalities were integrated and the correct operation of the application verified. And (5) the testing phase, where all the errors found were corrected [11].

2.1 Application architecture

Fig. 1. describe components of the solution, a smartphone with Android OS version 4.0 (or higher). The camera is activated by application and the Vuforia engines creates a captured scene frame; It treats the image by searching for matches in the database where the objectives are located. Once identified, its apply the logic programmed in Unity, displaying the virtual content on the screen of the device.

Fig. 1. Architecture of the IdeAR App.

2.2 Prototyping the application

Fig. 2. describe some functionality according to the literals. (A) Shows the start menu of the application where the child can also decide the virtual book option, which can be seen in the figure (B). (C) Shows the augmented reality of the story,

(D) access to the story glossary, (E) reading the story (text) with built-in glossary and (F) quiz module to validate reading comprehension.

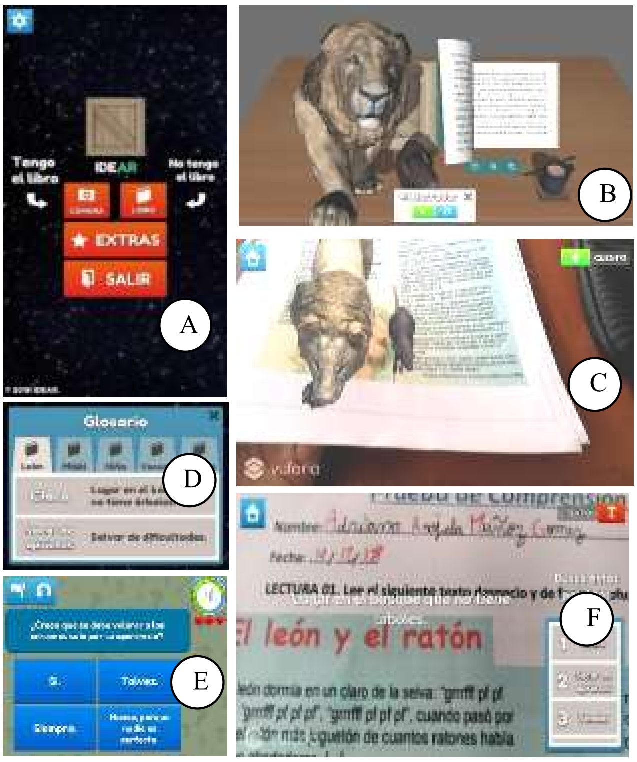

Fig. 2. IdeAR App interfaces.

III. Evaluation

This applied-type research aimed at demonstrate the influence of AR-based mobile application on reading comprehension levels through stories in school-age children.

3.1 Participants

The design adopted was quasi-experimental (see formula 1) applied a non-probabilistic sample of 58 students out of a total of 112, who take the Integral Communication course and attend the fourth grade of primary education of a public school in Lima city. The children's age ranges were between nine and ten years and the sample was divided into two groups of 28 students each (pre-established classrooms). The AR-based mobile application was applied to an experimental group (Ge) and the results were contrasted with those obtained by the control group (Gc).

$$\begin{array}{llll} Ge & O1 & X & O3 \\ Gc & O2 & - & O4 \end{array} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, Ge is the experimental group that receives the stimulus. Gc is the control group that learns in a conventional way. X is the stimulus: mobile application with RA. O1 is the pre-test (experimental group). O2 is the pre-test (control group). O3 is the post-test (experimental group). O4 is the post-test (control group).

IV. Results

The data were analyzed and interpreted in a descriptive way. Finally, was demonstrated the use an AR-based mobile application influences reading comprehension in the fourth grade of primary school in the course of integral communication of the Manuel Gonzales Prada School 6068.

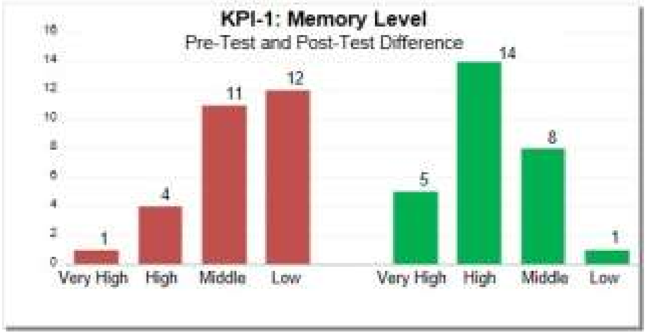

Fig. 3. Students' memory level before and after using the IdeAR mobile application

The first key performance indicator, KPI-1 referred to the measurement of the student's memory level when solving the reading comprehension test, indicates that in the pre-test only one student reached the very highest level, and in the post-test this measure rose to 5. The high level also increased from 4 in the pre-test to 14 in the post-test. Likewise, there is a considerable decrease in medium and low levels. Therefore, the “IdeAR” mobile application positively influences the memory level (post-test) with respect to the sample to which it was not applied (pre-test).

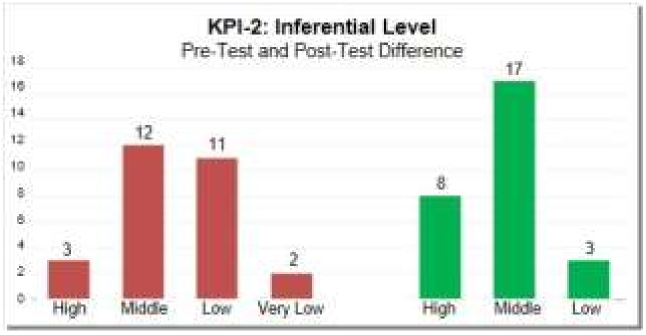

Fig. 4. Students' inferential understanding level before and after using the IdeAR application

The KPI-2 measurement referred to the inferential understanding level of the students when solving the reading comprehension test, indicates that in the pre-test, three students obtained a high level and in the post-test this measure increased to 8. The middle level was increased from 11 in pre-test to 17 in post-test. Likewise, there is a considerable decrease in the low level. The “IdeAR” mobile application positively influences the level of inferential understanding (post-test) with respect to the sample to which it was not applied (pre-test).

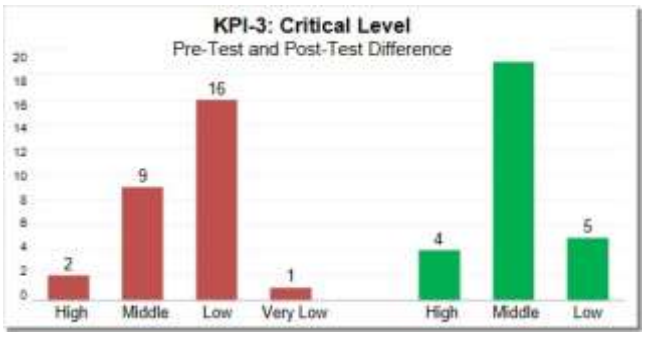

Fig. 5. Students' critical understanding level before and after using the IdeAR application.

The KPI-3 measures the critical understanding level of the students in the resolution of the reading comprehension test. Thus, 2 students obtained a high level in the pre-test, and in the post-test they increased to 4. The middle level also increased from 9 in the pre-test to 19 in the post-test. In addition, there is a considerable decrease in low levels. The mobile application "IdeAR" positively influences the critical level (post-test) with respect to the sample to which it was not applied (pre-test).

V. Conclusions and Future Works

In a context where reading comprehension is related to the academic results of the STEAM areas, this study result takes relevance.

The first conclusion has to do with the students' memory level, having two groups measured, the level of memory for each group, in the room "A" the memory level was low, while room B its memory level increased positively. Students who used the "IdeAR" mobile application obtained a very high score of their level of memory, confirming the correlational study [1] that determines a relationship between student' reading comprehension and their academic performance.

The second conclusion has to do with the student' content inference level relation, having two groups measured the level of content ratio inference for each group, in the room "A" the level of content ratio inference was low, while the room B its level of content ratio inference increased positively. Students who used the "IdeAR" mobile application scored very high in terms of their level of content inference.

The third conclusion has to do with the critical understanding level of the students, there being two groups, in the room "A" the critical level was very low, while room "B" its critical level increased positively. The students who used the “IdeAR” mobile application scored very high on the critical comprehension level.

It is concluded that, the use of a mobile application based on augmented reality to read “IdeAR” stories positively influence in children's reading comprehension, measured through their dimensions, in addition to generating greater motivation towards reading by children.

Finally, the integration of mobile technology and augmented reality is a very valuable tool to be used in the classroom and outside. Nowadays is necessary to make use of new pedagogical models, which allow to extend the classroom with activities before, during and after school; In that sense, augmented reality offers many advantages over the traditional way of reading a story, new proposals are expected in the implementation of easy frameworks for editing and programming content with augmented reality and planning evaluations by teachers in schools.

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