Augmented Reality Board Game for supporting learning and motivation in an indigenous community

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***Abstract*— Teachers and Designers of educational technology are interested in implementing different technologies in the classroom, mainly because they have benefits for the learning and teaching process. Thus, studies over the implications of certain technologies ought to be done. In this paper, we present an experience on the utilization of an Augmented Reality Board Game (ARBG) Co-Designed by Teachers and Designers. The ARBG was used in a case study with Teachers and Students from an indigenous community shelter in the Colombian southwest where The Teachers proposed, as the Learning Objective, the appropriation of traditions and family values of the community. This study shows the process of design of the ARBG, the evaluation in the classroom and the results on Learning Gains and motivation which was conducted in-situ with students from the indigenous school with positive results.**

Keywords*— *Augmented Reality, Board Game, Game-Based Learning, Technology, Indigenous Communities

I. INTRODUCTION

In the last decade, Game-Based Learning and applications with Augmented Reality (AR) have received attention due to their impact, utility and great potential in the educational field [1] and also due to the increase in the use of Information and Communication Technologies (ICT) in the classroom. In fact the union of both has been already proposed as having advantages [2]. However, there is still a need to observe how these technologies benefit in the teaching-learning process.

We decided to carry out the evaluation of an Augmented Reality Board Game (ARBG) in a case study in terms of motivation and learning in students belonging at "Miravalle" Educative Headquarter, located in "Las Mercedes" indigenous shelter in Caldono – Cauca, department of Colombia. Nasa indigenous community has more than 186,000 members; more than 85% of the community lives in Cauca. Their native language is Nasa Yuwe, only but 41% of the members still speak it. Our objective with the ARBG is to strengthen the educational processes of appropriation of the traditions and values of the Nasa culture.

"Cuetaya: Tierra de Colores" (Cuetaya: Land of Colors) is an ARBG Co-Designed with the active participation of Nasa teachers, who found in this tool an opportunity to know, practice and transmit knowledge of their culture to their students. This knowledge includes doing tasks like planting, weaving, collecting and resource exchanging.

To evaluate the ARBG we follow a methodological process of evaluation. We define the research questions, the population sample and the units of analysis. With this, we perform the collection of data and their respective quantitative and qualitative analysis.

The results of the ARBG evaluation process were positive and allowed us to observe positive aspects in learning and motivation.

The next section shows a brief description of the related works. In section 3, we define the proposed methodologies for the development and evaluation of the ARBG. In section 4, we describe the ARBG. In section 5, we show the results of the ARBG evaluation. In section 6, we discuss the results obtained and finally, in section 7 we present some conclusions.

II. BACKGROUND

AR has been one of the most promising tools for teaching and learning process over the last few years [3]. AR has as main advantages an increase in the learning gains, the motivation, interaction and collaboration [4] which are essentials aspects in the lifelong learning.

The combination of AR with games allows improving the learning experience, enabling connections of digital contents with the real world, enriching the perception of the environment, achieving greater attention and better knowledge of reality [2]. Due to this, some experiences have been developed in recent years [5], [6], [7], [8], [9] which use both technologies with satisfactory results.

ARBG is a recent approach with few experiences such as [10], [11], [12]. The experiences show that ARBG maintain concentration levels, allow using creativity and help to develop

ISBN 978-84-697-3849-8

high level cognitive skills; however, they have not been developed with direct participation of the teachers, under fully collaborative schemes [1].

To contribute to the learning-teaching process using technology in the classroom we focus on the design of an ARBG incorporating a Co-Design methodology. The methodology allowed us to involve the teachers in all the stages of game design and development, in order to consider the specific educational opportunities and the constant feedback of the teacher. These aspects allowed us to achieve valid characteristics that maintain the playability of students and balance the playful and learning component.

III. METHODOLOGY

This section describes the methodology followed to develop the game and the methodology followed to evaluate it.

A. Development

We developed the ARBG following the method for CoDesigning Game-Based learning with Augmented Reality with Teachers (Co-CreARGBL) defined by Tobar, Fabregat and Baldiris [1].

Cuetaya was created as part of the validation process of CoCreARGBL. This methodology proposes three stages (Training, Iterative Design and Classroom Evaluation). Each stage includes activities and roles (Leader, Designers, Developers, Researches, Teachers and Students).

All the roles work hand-in-hand during the activities proposed by the method. These activities are: Specification, Analysis, Design. Development, Implementation and Evaluation. Dring the first activities designers, developers and teachers work to create documents, artifacts and prototypws which then are used in a classroom by teacher practitioners.

In our process, two Leaders acted as the managers. They accounted for the quality of the product and the training process of the Teachers. Also gave support to the other roles. The Designer was in charge of scaffolding the ideas of the Teachers to turn them in to an ARBG. The Designer, being expert on Game Design and AR was able to guide Teachers for propose good ideas of games with the available technology.

The project had 4 Developers: 2 artists and 2 programmers. They offered ideas and restrictions from the development perspective. These developers used the Unity3D video game engine with AR Vuforia package that includes 250 AR Markers (ARM), Visual Studio 2015 development platform with C# programming language and 2D and 3D design tools like Paint Tool Sai, and Blender. The Researcher planned the research process and he was supported by the Development team.

The Teachers, proposed the main learning objective, which was “To strengthen the appropriation process of Nasa indigenous culture”. Also they proposed the educational content which included topics like language, culture, traditions and values. They created paper prototypes, designed documents and provided game resources like illustrations, dialogues and audios.

Teachers selected Students, which were designers, game testers and final users. Also Students provided names for the characters and audios for the game.

1) Stages and Activities

Stages were the phases in which all roles worked. In each stage we made a set to activities and in each activity there were a series of considerations. At the Training Stage Leaders, Designers and Researchers took the instructor role. They presented to the teacher the concepts of AR and GBL, the advantages, uses and principles of these technologies. During the first activity, teachers played and experienced AR using mobile applications. They learned the basic principles of CoDesign and the different uses of AR. In the second activity, teachers played educational games and recognized the importance of playful learning in the classroom and the properties of good games for learning by Gee [13].

During the Iterative Design, Teachers, Designers and Leaders worked to design and develop the ARBG. This was as part of the Specification, Analysis and Design Activities proposed by Co-CreARGBL. Teachers proposed the main ideas which included using the game as a way to show the surroundings of the indigenous shelter and other ideas. But finally, the Teachers proposed to include the traditions and values. This led to the use of an ARBG which uses a board with main “places” where the traditional work is conducted, such as the maize field for the crops or the mountain where they traditionally gather resources. Using this, the developers incorporated the changes so that the game was built.

During the Specification activity, Teachers wrote a document, which included the learning objective, the educational content and the learning materials.

For the Analysis activity, Teachers and Designers analyzed learning objectives to define an idea of ARBG. They created a document with the main idea of the game, the objective of the game, the conditions of victory and end of game.

At the Design activity, Teacher, Designers and Developers created a document with interfaces, game flow, emotional effects, real elements, actions and rules. The developers (programmers and artists) transformed the paper prototypes into digital elements. In the Development activity, developers worked under the SCRUM methodology [14], which allowed us to develop a functional ARBG with good work practices in a

short time.

Following SCRUM the team planned and designed the prototype. The team defined and created roles, product backlog, user stories, architecture, class diagrams, duration and number of sprints. The team used Model-View-Controller (MVC) architecture [15]. It gave us advantages such as code reuse, modularity and maintainability. The team planned and

ISBN 978-84-697-3849-8

executed the sprint, the review, and the retrospective. This process was repeated for each sprint. Finally, the team made the closing of the development process creating three documents, users and installation manual and printing instructions. The ARBG installer was uploaded in the Google Play Store [16]. The team created five ARBG packages for the evaluation Stage. Each package included main and secondary board, ten pieces for symbols and two pieces for characters.

We performed the Implementation and Evaluation activities proposed by Co-CreARGBL as part of the Evaluation process next.

B. Evaluation

We evaluated the ARBG following the case study design methods of Yin [17] and Shaw [18], which take the following: Selection of the sample, Units of analysis, Research questions, Collection of information and the respective Analysis, as described in Fig. 1.

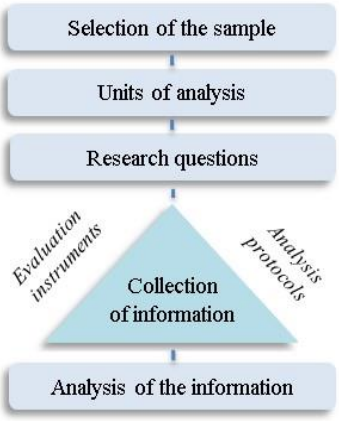

Fig. 1. Methodological procedure for the evaluation of the ARBG, adapted version of Yin [17] and Shaw [18]

1) Selection of the sample

We selected as population sample the students of the Nasa indigenous community, Cauca department, region of Colombia. This community is composed of low-income families who live in distant places of urban areas. The students have been influenced by the globalization and western traditions that are gradually coming to their communities.

2) Units of analysis

We defined, as unit of analysis, 20 students of fourth and fifth grades of elementary school, average age of 10 years old, and standard deviation of 0.86. They belong to the "Miravalle" Educative Headquarter, located in "Las Mercedes" shelter in Caldono - Cauca.

3) Research questions

We proposed the following research questions:

- How using an ARBG developed with active participation of the teacher can contribute to the teaching-learning process?
- How do students learn and get motivated using an ARBG for Learning?

4) Collection of information

We defined the evaluation instruments used to evaluate learning and motivation of the students after interacting with the ARBG. For it, we considered the social context of the students and the "*Sistema Educativo Indígena Propio*" (SEIP) (the educational system used and proposed by the indigenous community) [19], which expresses that the teacher must evaluate qualitatively the students from appreciations, perceptions and observations.

To evaluate the learning in the students we defined a diagnostic evaluation, a formative evaluation and final observations. This was done to have an evaluation before and after performing the whole process and in this way, to develop a comparative study.

In the diagnostic evaluation, we sought to determine the previous knowledge and deficiencies that students have about their culture: traditions, values, beliefs and language. For the diagnosis, the teacher asked and exchanged ideas with his students.

Once the diagnostic evaluation and the ARBG game activity was finished, we conducted the formative evaluation to determine, understand, analyze and conclude the learning, motivation and interest of the students during the ARBG activity. To do this, we asked the students to draw posters, which allowed them to demonstrate what they had learned and show their teachers how motivated and interested they were when interacting with the ARBG.

The teachers expressed their perceptions, appreciations and observations of the two evaluations. They shared the positive and negative results. Additionally, we conducted the thematic analysis of the information gathered during the three activities, in order to quantify it and extract results and conclusions. The protocol used is described in Table 1.

TABLE I. PROTOCOL FOR THE THEMATIC ANALYSIS OF THE INFORMATION

Steps	Actions
1	Determine a set of categories in which the information obtained from each student will be classified for each evaluation and final observations.
2	Define an analysis template for the categories and the data collected from the evaluations.
3	Ask evaluators (coders), who read all the information obtained by each student, to classify it in the defined template.
4	Integrate the evaluations, if there are differences consensus should be resolved with debate to find agreements.
5	Making a statistical report of the categorized data.

ISBN 978-84-697-3849-8

To evaluate the motivation, we adapted the contents of the learning objective into a virtual book in the form of a webpage that was handed to the students accessible through tablet devices. To gather information about their self-report on motivation we adapted the Intrinsic Motivation Inventory (IMI) motivation test defined by Ryan [20]. The test included questions grouped into three sub-scales: interest and enjoyment, effort and importance, and value and utility. The objective of the test was to know how the students felt using the ARBG versus the virtual book. This was done to find out which one offers better results. The protocol used is described in Table 2.

As an additional instrument to evaluate learning and motivation, we conducted interviews. Through them, we looked for students to express verbally what they had learnt enjoyed, and how motivated they felt after doing all the activities.

TABLE II. PROTOCOL FOR THE ANALYSIS OF MOTIVATION TEST

Steps	Actions
1	Define a template where the basic information of each student and their responses of the test.
2	Calculate the average and deviation standard for sub-scales.
3	Making a statistical report of these calculations.

With the evaluation and analysis protocols in mind, we prepared a class with the selected students. The class was conducted by the Teacher with the help of the Researcher and the Developers. The teacher moved with the students to a quiet place in the middle of the nature where they held a discussion for the diagnostic evaluation. The teacher asked about the traditions and culture concepts and students answered freely. This showed how students had previous knowledge and deficiencies.

Back in the classroom we divided the students into groups of three students; we distributed a tablet device to each group so they could interact with the virtual book for 20 minutes. After a while, students lost interest in the virtual book.

Then we proceeded with the game session, each group was assigned a package of the ARBG game. The students interacted with the game as shown in Fig. 2. They all finished the ARBG before 25 minutes approximately.

IV. DESCRIPTION OF THE ARBG

"*Cuetaya: Tierra de Colores*" is an ARBG whose objective is to get the characters to conform a Nasa traditional family. For this, they must obtain and harvest three maize crops, weave a traditional hat, weave three "*jigras"* (traditional handbags) and build a house. Players can obtain them gathering basic resources like maize, building materials, wool, straw and *"cabuya"* (a knitting material). These are obtained working in each place or exchanging them in the barter area. Players have a limited time to collect them. This time is equivalent to a Nasa lunar calendar cycle which ends when the moon goes through 21 epochs; the whole cycle takes about 20 minutes of game.

Fig. 2. Students playing the game during evaluation in the classroom

Players lose the game if time is over and they did not obtain the requirements.

Cuetaya is composed by a set of boards and pieces. The set contains ARM and a digital application for Android tablets. The main board has three sections. A central section with five ARMs, one for each work place: maize field, mountain, weaving place, place for constructing the house and one ARM for the Nasa Calendar. The game also has a lateral section for the barn zone which has five ARMs, one for each resource. The other lateral section is for the barter zone with four ARMs for the basic game resources except for the maize because this is the currency used in the game. Cuetaya has ten pieces for the *"chumbe"* symbols (traditional symbols that grant gifts to babies under the Nasa traditions); each of these is an ARM. Finally we have two pieces for each character; each one is an ARM too.

Players interact with 26 ARMs, these provides virtual information like 2D illustrations, 3D models, virtual buttons, sounds, voices, explanations and others contents. In Fig. 3, we can see the game package. For a game session, it is necessary to install the application in a mobile device with Android 4.1 or higher and print the Cuetaya package which can be downloaded from the app downloading site.

The educational content was defined by the teachers, based on the SEIP. The subjects are related to the tasks that the player must to do. Players learn Territory and Society by observing the board, knowing the places of work and what they offer them, Community and Nature, working in the mountains and collecting resources, Communication and Language, interacting with concepts and pronunciations in Spanish and Nasa Yuwe, Mathematics, for managing and exchanging the resources.

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V. EVALUATION

A. Learning

We performed a thematic analysis over the diagnostic, formative evaluations and final observations for each student, following the protocol in Table 1. Teachers gave us their concept for each evaluation. The concepts were analyzed by two independent coders who classified the answers using the code format <Category>:<Specification>:<Theme>.

Categories referred to a general concept like previous knowledge or deficiencies. *Specification* referred to a concrete concept like "the recognition of some concept". The *Theme* defined the concept associated to the evaluation, for example: family, beliefs or traditions. Coders used a template to evaluate each student. Disagreements in the classification were discussed and agreed upon final set codes. Finally we defined a co-occurrence matrix with the codes aiming to observe the most frequent topics in the classified information, taking into account the associated specification and the category.

The matrix allowed us to observe that in the diagnostic evaluation the students showed to have previous knowledge of themes like be Nasa, Nasa Yuwe, Nature and Family. However, we evidenced deficiencies in the following themes Nasa calendar, Moon phases and Rituals.

themes like Nasa calendar and Rituals showed positives outcomes contrasted with the deficiencies that were evidenced during the diagnostic evaluation.

TABLE III. LEARNING EVALUATION RESULTS

Evaluations	**Classification format**		
	Category	***Specification***	***Theme***
Diagnostic evaluation	Previous knowledge	Recognizes	Family, nature, Nasa Yuwe, beliefs and traditions.
	Deficiencies	Not Recognize	Nasa calendar, moon phases and rituals.
Formative evaluation	Learning	Gives Importance	House construction, family, moon, nature, maize sowing and traditions.
Final observations	Positive result		Nasa Yuwe, maize sowing, *"chumbes"*, exchange of resources, Nasa calendar and rituals.

B. Motivation

We analyzed the information collected in the tests following the protocol in the Table 2. We created a template for

Fig. 3. Cuetaya Boards an pieces Package, main board, secondary board, pieces for chumbes symbols and pieces for characters

Regarding the formative evaluation, we concluded that the students, through the drawing, expressed a strengthening of concepts related to themes like The House Construction, Family Values, Moon Phases, Maize Crops and sowing and other Traditions. These themes were seen during the ARBG experience.

In the final observations, the thematic analysis showed positive results in themes like Nasa Yuwe language, Maize sowing, *"Chumbes"* and Exchange of resources. Additionally, transcribing each test, storing the basic information of each student and classifying their answers in a numerical scale of 1 to 5. We compared the self-report on the motivation with the ARBG versus the virtual book for each sub-scale selected from the IMI. Fig. 4 shows the results of this comparison.

Based on these results we observed that the students enjoyed and were more interested using the ARBG than the virtual book. The virtual book had an average of 3.98 and the ARBG of 4.88, the students dedicated more effort and importance to

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ARBG, while the virtual book obtained 3.84, the ARBG 4.82. They felt that it was more useful the ARBG than the virtual book, with averages of 4.79 and 4.24.

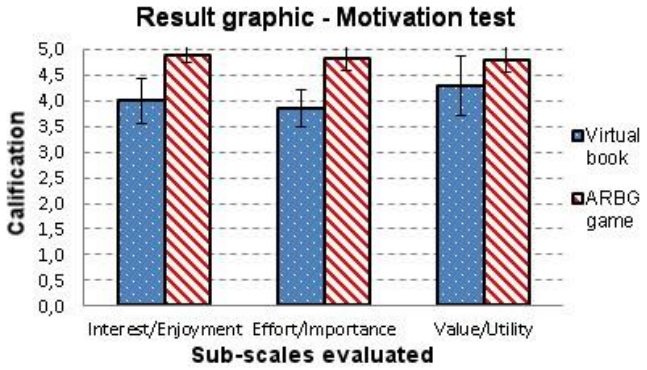

Fig. 4. Motivation Results.

VI. DISSCUSSION

Cuetaya is a multidisciplinary co-designed ARBG. It relied on the work and contribution of experts in video game design, researchers, developers, graphic designers and teachers. With the ARBG we use technology and mobile devices to support teaching-learning processes in classrooms which allow teachers to teach their own traditional educational content through a gaming experience. The game makes it possible for students to recognize concepts and traditions of the Nasa culture. In this way, the students relate the concepts seen through the game with what they live in their daily lives.

However, when we implemented and evaluated the ARBG in classrooms, it was revealed that although the students appropriated concepts, it is not wise to generalize the results obtained, due to several factors such as the low sample population, the number of game sessions and the method of evaluation, because the SEIP handles a qualitative evaluation according to the teacher's appreciations of the students, which was a limitation of the project. However, Cuetaya showed to be a tool which can be used to strengthen the concepts discussed in the classroom. Regarding motivation, we observed that it is present in the interaction with the ARBG. There were high levels of motivation in the sub-scales evaluated. The union between games, AR applications and GBL seems to motivate teachers and students to learn and participate. Regarding the particular case study, ARBG becomes a way to include indigenous communities in the processes of appropriation and good use of technologies.

VII. CONCLUSIONS AND FUTURE WORK

We participated in a multidisciplinary ARBG Co-Design process, with professionals in several areas. We designed the ARBG named "*Cuetaya: Tierra de Colores*" (Cuetaya: Land of Colors in Spanish). This Design process was useful as a validation case for the Co-Design methodology used.

Cuetaya was Co-Designed and developed using the Co-CreARGBL methodology [1] and the SCRUM methodology [14] respectively. We evaluated the ARBG following the case study design methods of Yin [17] and Shaw [18]. The evaluation revealed positives results regarding the strengthening and appropriation of educational concepts included in the game and related with the Nasa traditions. Also, it showed greater motivation self-reports when compared against a virtual book with the same concepts.

We are committed to continuing the work done in the Nasa indigenous community, supporting the incorporation and good use of available technologies to improve teaching and learning processes. Future work includes a study with a bigger sample and more game sessions to obtain more detailed information about the students and their interaction with the game.

We hope that the process carried out and the methodology followed will be taken into account by the teaching community, seeking the incorporation and good use of available technologies such as AR and GBL in the classroom.

ACKNOWLEDGMENT

Thanks to Nasas and the teachers and students who participated on this project. This work was funded by University of Cauca (Code: 4565 and 4573), the DURSI group CSI (*ref. SGR-1469*), the Open Co-Creation project grant TIN2014-53082-R and the UdG's grant MPCUdG2016.

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ISBN 978-84-697-3849-8