AR BOOK AS IMMERSIVE READING TOOL FOR ALLOWING THE READER TO BE PART OF THE STORY

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ABSTRACT
Reading is one of the most important skills children develop for acquiring new knowledge and enhancing thinking and memory. Current technologic advances are changing how people interact with books, the availability of computing devices in the form of laptops, smartphones and tablets allow enriched reading experiences through transmedia interactive content. Traditionally, book immersion was accomplished using figures and the reader’s imagination, and their interactivity came with popup books that attracted attention by offering movable 3D objects. Currently, electronic books offer more immersive and interactive form of reading through multimedia content. In terms of immersion augmented reality offers spatial navigation of contents similar to real life environments.

The importance of 3D as a tool for offering more information about a specific scenario has been taken place in reading documents, such as interactive PDFs, Apple iBooks, and augmented reality booklets used in training, maintenance, education and games. The goal of this project is to develop an augmented reality book that allows a young reader to navigate the story and shape its development through choices represented by augmented virtual animation over a booklet containing fragments of the story.

KEY WORDS
Augmented Reality, Education, Interactive Storytelling.

1. Introduction
Lower levels of reading skills can lead to elevated number of social inequity, currently, reading habits are being promoted apearly ages[1].The interest of massif development of social skills has resulted in the development of programs for promoting and encouraging reading practices at early stages in children development[2][3].Globalization of Information Communication Technologies (ICT) is leading to a shift in how many activities are accomplished currently in society, and reading is not an exception. Statistics regarding number of tablet users and their usage impact in academic environments are rising, even old cellular phones and SIM cards are being converted to e-readers for offering a low cost alternative that benefits students in Philippines from developing column deviation problems and lack of textbooks accessibility [4]. Reading habits studied by the Progress in International Reading Literacy Study show the existence of low levels of reading skills in several countries [5].

Digital forms of media allow integrating several forms of participative activities that enrich the reader’s experience; online dictionaries, commentaries, social sharing, and cloud-based synchronization features are some examples in this trend. However, despite of massive electronic readings and its advantages, immersive and interactive books still caught young readers attention, examples of these can be seen in pop up and flipping books that allow further interaction with the contents. Similar approaches have been taken with current technologies such as Augmented Reality (AR), the Hello (Handheld English Language Learning) system was developed for motivating English learning [6]; the MagicBook uses AR as a complement of a traditional book whose content is enhanced when using special glasses[7][8] in a study is presented for the development of an AR for hearing impaired students based on visual and interactive techniques; in [9] an AR book for standard mobile phones was developed for viewing comics for children in 3D; these advances in AR-based books yielded for further development in easing the authoring process, the ARBOOKCREATOR proposed such alternative without require commercial software or advanced programming skills [8], with an educational approach the HUMANAR AR library was compiled for use with an anatomy study book with the goal of taking advantage from students motivation and interest with 3D interactive content [9].

These developments among many others highlight the impact of AR, the 2013 Horizon Report considers AR as an important educational tool in an era where tablets and Smartphone are widely used[10], however, current approaches attain immersion with enhanced 3D computer graphics and multimedia interactive content. The impact of AR applications can be enhanced through game mechanics that motivate readers through defined goals, interactive rules and feedback that compels the user to use the AR book.
This paper presents the development of an AR book for children that allows them to navigate, explore and alter the course of the story by selecting different paths during the reading. The taken choices will also alter the environment and animations of each character for responding to what the reader chooses. The goal is to offer a complimentary book tool that motivates the reader into reading by presenting them choices accordingly to what they have comprehended from the passages in a gamified system.

The paper is organized as follows: in Section II the system architecture and its characterization is presented; in Section III the development and implementation of the AR book, in Section IV the results, and finally, in Section V the discussion and conclusions.

2. System Architecture

The proposed application integrates several elements by taking as foundation the structure of a book, a beginning, a development and an ending, accompanied by characters, environments and a plot. These elements allow defining the system’s architecture and each of the processes’ inputs and outputs as presented in Figure 1.

![Figure 1. System Architecture](image)

Inputs vary from the application elements and can be categorized accordingly. User inputs are subcategorized in two, one for the reader that allows navigation, visualization and making choices by selecting markers within the Graphics User Interface (GUI), and other for the instructor that allows configuring the story, actions and questionnaire for validating what the reader comprehended from the story. Story inputs are composed of markers, audio, video, 3D and content, from these, the instructor choses the corresponding media and content for displaying within the application. The inputs and their description are presented as follows:

**Inputs**
- **Markers**: Black and White pattern-based images for enhancing the real environment.
- **Book parameters**: text content, characters, environments and multimedia.
- **User Interaction**: content accessibility through GUI

The system outputs also vary accordingly to the inputs and can be subcategorized in the same manner. Reader outputs allow measuring through the questionnaire how well the text was understood, story outputs allow watching the multimedia content while interacting with it through the markers. The outputs are described as follows:

**Outputs**
- **Multimedia content**: interactive 3D, videos and audio.
• **Feedback**: results from questionnaire and made choices.

Associated to this inputs and outputs the following subsystems are identified for developing the application

- **Marker module**: Created markers are loaded, read and programmed to be recognized with the application events
- **Multimedia module**: Multimedia content (3D, audio visual and text are stored
- **Feedback module**: Stores questionnaire data and choices made by the readers

From these inputs and outputs the GUI has a real and a digital interface. The real interface is composed of a booklet containing story information and graphics with markers for using with the digital GUI. The digital GUI augments the booklet with virtual environments and animation representing the contents of each page according to the user choices.

Game elements can play an important role as learning is associated with game mechanics where the user entertains while performing the targeted activity [11][12][13]. Approaches in this area have resulted in developments such as, ReMission[14], where the game readings teaches about cancer treatment; Escape from Diab[15] promotes healthy nutrition; and finally, Transcription Hero [16] allows the user to act as a RNA (Ribonucleic acid) that travels through a DNA (Deoxyribonucleic acid) sequence whose goal is to carry a gene without causing mutations.

3. Application Development

The application development is achieved by solving each subsystem, covering the AR setup and programming, graphics design, content design and game mechanics. The chosen story for developing the application was *Little red riding hood*[17], this tale, written by the Grimm brothers allows gathering sociocultural aspects such as innocence, bravery and sharpness developed during the story, providing not only a happy ending but a valuable lesson for children.

3.1. AR booklet

A booklet was design depicting story aspects through text, graphics and markers that show virtual environments and animation related to each page contents. The booklet design is presented in Figure 2; from it the graphics text and markers can be seen. Each page contains three markers; the biggest marker shows the animation that change by triggered events chosen by selecting one of the smaller markers.

3.2. Content design

Considering the ambient of the chosen story, five characters were designed, the hunter, the grandmother, little red riding hood, the wolf and the wolf disguised as the grandmother as presented in Figure 3.

Three scenarios were designed for developing the story, the first a forest with a path for the main character to follow, the second the grandmother’s house, and the third the grandmother’s bedroom as presented in Figure 4.
Along with the visual content, the text, questions and questionnaire were supervised by a reading instructor from an elementary school who assessed the correct setup, grammar and objectives within the context of the chosen story.

### 3.3 Game Mechanics

Immersion through AR is interesting enough, however it is not the only component for attracting young readers, in fact, 3D may lead to distraction due to the navigation of the scenarios. For tackling this possible problem, a gamified system is proposed for motivating the readers in following and completing the story with some degree of liberty for being part of the story rather than see how it develops.

The first element to define is the goal, which in this case is complete the reading by navigating through three different scenarios that require actions from the reader for continuing from a section to the next. The second element are the rules for completing the goal, in this case the reader is required to answer two questions, one at the beginning and at the middle of the story for shaping its development, and a questionnaire at the end for checking how much was understood from the experience. The questions are answered from selecting sliding markers within the pages accordingly to what was comprehended and the user can only go forward by answering the questions. The third element is feedback, which is provided in the form of happy face when the answer was correct and a worry face when it was not, the objective with these was to encourage the reader in paying attention and not give him a penalty for failing. Additionally, the responses are stored for further analysis by the reading instructor, and these are presented to the reader for letting him know how he performed. The final element is the strategy for getting the readers to voluntary use the application; this is accomplished through the visual design and game elements which causes interest among children.

The interaction flowchart is presented in Figure 5; it presents how the reader moves through the application from the start of the story to its unfolding.

![Figure 5. Interactions Flowchart](image)

### 4. Results

The application was developed using Processing and exported as an executable file playable in both Windows and MacOS computers with an external webcam. The application was tested with children with ages between five and seven years old. A screen capture from the implemented application is presented in Figure 6 where it
can be seen the grandmother’s bedroom, part of the booklet with text and the happy rewarding faces.

Figure 6. AR Content

For applying the test an informatics classroom was set up with computers having a webcam and the booklet for the children to use. First impressions of the material caught the attention of the children as they were curious to skip the explanation and start playing with the booklet and the computer. Once the instructions and game mechanics were explained the children started using the application. During the experience the children showed reactions such as wonder, curiosity and became aware that the animations did not tell the entire story so they became concentrated in the story while enjoying the animations and answering the questions. At the end of the experience the children were asked to solve the questionnaire and to draw what was understood from the reading, this activity was performed with children using the application and children using the booklet.

The formulated questions were: what was the story about?, do you think little red riding hood will disobey her mother again?, and finally, what did you learn from the story? Figure 7 and Figure 8 presents children using the application with guidance of an instructor.

Figure 7. User evaluation (5 years old)

Figure 8. User evaluation (7 years old)

Results from both practices showed that both groups of readers were able to make drawing representing what the story was about in two cases forgetting some characters. The questionnaire showed a difference in correct and wrong answers as readers who used the application got more correct answers than the others. The children were asked why they got more correct answers, their responses were that the application caught their attention and they became more interested in knowing what was going to happen, and others thought the application was cooler than the booklet.

The application is not only intended for impacting young readers, teachers are also impacted with the development of this application. The chosen development platform allows with dedication use open source software such as Blender3D, Inkscape, gimp and Processing for developing simple augmented reality applications.

After completing the activities with the children, a survey was applied to teacher to see their technology knowledge, familiarization and appropriation as complimentary educational tools. The survey consisted on 13 questions,
from them, four were more relevant to the presented project and their results are presented as follows in Figure 9, Figure 10, Figure 11 and Figure 12.

5. Conclusion

Augmented reality still holds potential for amaze users, however its novelty is susceptible of losing attention if relied only on the augmentation of scenario. Performed tests with the children and the survey with the teachers proved that an AR-based book with game mechanics impacts positively reading comprehension, as the readers were able to answer the questions by reading the story while immersed and not distracted by the virtual environments and animations. The combination of a booklet with the story was also effective because while the AR experience depends on having a computer, a webcam and the booklet, the reading can be done with just the booklet.

Finally, the application is not constraint to a specific story, different models, questions and actions can be altered, resulting in a flexible development that allows merging with any tale. Due to its acceptance, future works may involve further developments in more detailed environments and complex stories.

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References


