

Augmenting Reality in Books: A Tool for Enhancing Reading Skills in Mexico

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Abstract Data suggests there is a global reduction in the number of readers, and a decreasing amount of time spent on reading. The primary reasons for this falling performance is due to the lack of time to read and the lack of motivation. Augmented reality has a promising potential to increase literacy because it fosters cognitive attainment and has a positive impact on overall learning effectiveness. Augmented technology contributes to increasing engagement, invites participation, and develops appreciation of the context. Augmented books are proposed to incentivize curiosity, facilitate the interpretation of text and illustrations, and provide a learning tool that relates to the reader. The Mexican national textbook publishing program has an unparalleled opportunity to *improve educational outcomes since augmented reality provides complementary digital learning experiences* to the printed content giving readers the advantage of two media. Net result: increased literacy, deeper learning.

Keywords Augmented reality · Augmented books · Learning · Literacy · Motivation · Technology

Augmented Reality: Description of the Technology

Although there is no such thing as a formally agreed definition of augmented reality [39], it has traditionally been described as the capability to incorporate real-time 3D computer graphics into a person's field of view in such a convincing way that they seem to be as real as the physical objects surrounding them [34]. Caudell and Mizell [11] framed the concept 'augmented reality' in the early 1990s, but today the significance of the concept is broader than the origins. Augmented Reality is

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depicted as broad as the method to superimpose virtual objects onto the real environment [45]. Industry actors and marketing professionals prefer the usage of similar diffuse descriptions of virtual reality, because they want to easily generate hype to foster the advertising of their products [30]. However, scientists and academics are particularly critical about the implications of ample definitions and that is why in an effort to clarify criteria, Azuma [3] narrowed the term as: “systems that have the following three characteristics: (1) Combines real and virtual (2) Interactive in real time (3) Registered in 3D” (p. 356). The objective of augmented reality systems is to integrate the interactive real world with an interactive computer-generated world in such manner that they appear as one environment [43]. Augmented Reality mixes virtual and actual reality, making new tools available to the user to ensure efficiency in transferring knowledge for several processes and in several situations [22]. Augmented reality allows digital content to be seamlessly overlaid and integrated into our perceptions or the real world, because not only incorporates 2D and 3D objects, but also digital assets such as audio, video files, graphs, texts, and multisensory information [57]. Although virtual reality and augmented reality share the objective providing an immersive user experience [26], the difference between them strives that in augmented reality the user maintains connection with the real world, and that means that wearing a device is not necessary [28], while virtual reality is commonly achieved by wearing a helmet or goggles [36] allowing individuals an opportunity to transcend the real world by creating a fantasy world [16].

Augmented reality technology is a relatively new market, but it is rapidly maturing [19]. According to Goldman Sachs, the investment banking firm, the virtual and augmented reality technology has the potential to become the next computing platform and it is expected to generate at least \$80 billion in revenue by 2025 [6]. ABI Research [1], a leader in technology market forecasts, projected that augmented reality will reach approximately \$100 billion in total market worth by 2020; and the firm Digi-Capital [37] predicts even higher numbers reaching market sales of more than \$150 billion by 2020. Fortune magazine explains that “augmented reality’s addressable market is similar to today’s smartphone and tablet market, where there could be hundreds of millions of users and price points similar to smartphones and tablets” [17].

Augmented reality is used in a wide variety of industries and solutions ranging from games to medicine and from aeronautics to movies [15]. Especially for education, augmented reality has a promising potential [44]. The educational experience offered by augmented reality can be valuable, because supports seamless interactions between real and virtual environments, uses a tangible interface metaphor for object manipulation, and smoothly facilitates the transition between reality and virtuality [8]. Reviews of the potential of augmented reality within education is described as a purely visual phenomenon [35]. However, augmented reality is also experienced not only by sound and haptics [5] but also by olfactory and gustatory sensations [39]. In addition, augmented reality supports learning activities that go far beyond passive ‘desktop computer’ information presentation allowing a more dynamic, engaging, and effective learning tool [41]. Augmented

reality is increasingly used on mobile devices in order to enhance learning activities [27].

Literacy Challenges

Literacy is a fundamental human right and the base for lifelong learning [48]. Although there are different definitions of literacy, a widespread description of the term is: “a set of tangible skills—particularly the cognitive skills of reading and writing—that are independent of the context in which they are acquired and the background of the person who acquires them” [49]. Reading is the foundation for literacy [55]. Reading is defined as a “complex process of ‘literate thinking,’ where the meaning derived by individual readers is dependent on the contexts in which they read, the features and purpose of specific texts selected for reading, and the skills and knowledge required to interpret, analyze, and evaluate their meanings” [20]. Unfortunately, there is a growing concern about decreasing reading performance in several countries [40]. Data suggests that there is a global reduction in the number of readers, and a decreasing amount of time spent on reading [23]. In addition, there are multiple reading challenges including, but not limited to fluency, vocabulary, decoding, phonetics, comprehension, insufficient learning skills, limited background experiences, among others [38]. But, one of the most overlooked factors causing reading difficulties is disengagement readers, in other words, the lack of motivation to read [54]. Because motivation is not evaluated on standardized tests and it is considered a subjective metric, this important aspect of literacy is often ignored [42]. In spite of several studies emphasizing the importance of motivation for fostering reading skills, educational institutions are not reinforcing it enough [29]. Promoting literacy acquisition requires interventions to foster attitudes and beliefs as much as those that assure cognitive changes in learners [51]. Schools require pairing motivation practices with explicit reading comprehension instruction [47]. Another factor for low levels of reading motivation is due to students do not have enough reading role models [46]. Evidence suggests there is a lack of commitment to building student motivation to read [42].

Mexican Reading Challenges

In Mexico, every person has the right to free education, and both elementary and middle education are mandatory. However, by the end of the 1950s this principle of gratuity of the basic education was not totally being fulfilled because the textbooks were excessively expensive, the low quality content and the cost of books were inaccessible for most of the Mexican families [21]. In order to assure access to quality books, in 1959 the Mexican government created the National Commission of Free Text Books with the objective that each student would attend school with textbooks paid by the Government [2]. In most countries, publishing companies created educational content and supply books to governments; however, the Mexican publishing program is unique in the world because it is the only one in

which the government entirely designs, creates, produces, and distributes the books for free to the student population [53]. Until 2015, this governmental institution has published and distributed more than 5 billion books, and the book catalogue is wide an diverse providing books for pre-school, elementary school, middle school, telesecundaria, indigenous education (in 42 different languages), and Braille, among others [14]. In spite of the positive impact that the free text program has had in Mexican education for enhancing literacy [53], there is still ample room for improvement.

According to the World Bank [4], Mexican adult literacy rate in the population 15 years and above reached 94.56%. However, the average number of books read by the Mexican adult per year is 3.8 [25]. The primary reasons for this marginal performance is due to the lack of time to read and the lack of motivation. Although, there is no governmental data available for children [25], reasonably assumes that the numbers for young people follow similar patterns. In my experience as an innovation advisor for some educational institutions in Mexico, the lack of motivation for reading is frequently quoted as one of the top challenges for academic leaders. For example, an elementary school principal expressed: “why does a boy play video games or watch TV for 3 h, but he cannot stay engaged with books for 15 min?”

Augmented Books: A Proposal for Improving Mexican Reading Challenges

On the one hand, the paper-based book has been an effective tool for improving literacy in Mexico. The main advantage provided to Mexican children by the printed book, is that it is universally available and for free. Some of the strengths of printed books are transportability, durability, flexibility, and robustness [32]. On the other hand, electronic publishing technologies facilitates access to audio, video, and external internet links; it also makes content versatile, updatable, and available on demand [50]. That is why some people have proposed the replacement of paper-based books with new book technologies such as electronic paper devices, e-books readers, tablets, computers, laptops, notebooks, and even phones [18].

Thanks to augmented reality there is no reason to choose between paper-books or e-books. Since augmented reality books combine digital content with analogue books, readers have the advantages of the two media. An augmented reality book integrates the usage of pattern recognition technology in order to allow interactive 3D graphics and sounds to appear on a computer screen when interfaced with a webcam [57]. On paper-books, readers look at pictures, turn pages and read the text without any external technology. However, thanks to augmented reality displays, users can view additional multimedia materials such as three-dimensional (3D) virtual models or videos and manipulate virtual objects using real physical markers and natural motions [7].

Augmented books provide many advantages for improving literacy from the learning perspective; when augmented reality is integrated with picture books, being attractive and interesting to its users. In recent years, some educational augmented

reality books have been developed, and users have consistently demonstrated positive attitudes towards them [13]. Augmented reality books are effective to capture and keep the attention of students in the learning [56]. But more importantly, learning motivation increases when augmented reality is applied to a picture book [31]. Since lack of motivation is diminishing reading skills in Mexican children, the usage of this technology promises a reduction of this negative factor. Data suggests using digital elements to enhance traditional texts increasing children engagement and this is crucial to the development of literacy [33].

Augmented reality books also foster children's cognitive attainment and have a positive impact on overall learning effectiveness [56]. Augmented books may also improve students' cognitive skills via their embodied representations, since children showed better memory performance with physical interactive story content [24]. According to different studies, information learned through integrated augmented reality experiences is easier to remember than those originated separately by paper-pen activities or only videos [52]. Story memory recall and reading comprehension are also enhanced by augmented reality [9].

The purpose of my proposal is to incorporate augmented reality capabilities into the book program developed by the National Commission of Free Text Books. The objective is to introduce an effective way to enhance the content by incorporating digital elements to current book titles. There are many technological options to do this. Some of the augmented reality platforms include Zappar, Blippar, Gamooz, MagicBook, Alive Studios, among others. For example, each of these companies provides an app that adds augmented reality to paper books. The technology does not require printing special editions in order to generate digital content.

On the contrary, the app utilizes augmented reality content solutions based on the images of the books that are already available. The technology utilizes computer algorithms to analyzing camera images and then providing an immersive digital experience from videos to 3D animations. By using this kind of technology, children, teachers, and parents can use their current books of their libraries and personal collections. This technology can be really useful for the Mexican Government because it allows incorporating augmented reality to its ample publishing book catalogue. And as soon as the digital content is created, the augmented reality experience will be available for all children. Content can also be updated as needed. This technology works with multiple devices that incorporate a camera such as mobile phones, tablets, PDA, notebooks, laptops, desktop computers, among others.

From the economic perspective, the plan seems attainable because the cost developing augmented reality content will be marginal when is allocated proportionally into millions of books published by the Mexican Government. In addition, this proposal is based on enhancing the current book catalogue in order to avoid wasting or incurring on extra printing expenses; beyond the cost of creating digital content and the training of people to properly utilize the technology, it seems that this solution will have a moderate cost of implementation because relies on current digital infrastructure.

Model Case: Augmented Reality Enhances a Fourth-Grade Spanish Book

As it was described before, the governmental publishing program covers an ample spectrum of topics attuned to different educational levels and student needs. In order to clarify how augmented reality will be applied, let's review a specific case. Mexican fourth-graders utilize 8 texts books as a base for the curriculum. Particularly, literacy skills lessons are covered on the Spanish book. This book contains different learning activities including reading comprehension text, vocabulary exercises, grammatical rules, and writing assignments. Sometimes these activities are integrated performing one global activity in order to provide a cohesive learning experience. For example, there are activities in which the student's goal is reading an introductory text, reviewing new vocabulary, practicing pronunciation of key words, reinforcing one grammatical rule, and finally integrating knowledge by writing a short composition. There are many ways in which augmented reality can enhance this literacy learning activity:

(1) Reading. Thanks to augmented reality the student will not only read how and where the characters live, but also will use and immersive experience with videos and animations showing their towns, homes and main historical sites in detail. In addition, virtual reality will allow the student to view a 3D mural about the local Art. Augmented reality provides a richer context about a particular social group and facilitates reading comprehension. (2) Vocabulary. An interactive digital word game will appear on the screen. The student will practice new words and will also have fun. This will contribute to increase vocabulary and engagement. If the student gets a right answer, he wins a point. Later on he can exchange points for a special reward. (3) Pronunciation. The student will be able to play sound files and listen to correct wording pronunciations. The digital application will allow the student to connect those sounds to the words. Animated characters playing the role of children will pronounce the words correctly. Then, the student will be able to listen and repeat the words until necessary. In addition, he will be able to get to know clothes, and traditions. (4) Grammatical rule. By playing a simple game, the student will reinforce the importance of using capital letters at the beginning of a sentence. For example, the student will use the paper-book to identify sentence correction. The digital experience will provide a bell sound when the student selects correctly the capitalized letter. (5) Writing. Due to this cohesive learning experience, students will have a better understanding of the context of the culture, the language, traditions, and Art. Now, the student has more elements to write a colorful composition using the knowledge learned through the integrated multisensory lesson. As this example shows, there are many opportunities to enhance learning through augmented reality. But, more importantly, the student also becomes the co-director of his own learning experience. The student works at his own pace and reinforces concepts in a more engaging way. The student also learns by doing.

Approaches to Evaluate Learning

There are many ways to evaluate learning. First, by taking advantage of the evaluations already developed by teachers and in use for the Spanish books activities. Second, augmented reality provides data that can be used to quantify progress. For example, the percentage of correct answers in the vocabulary test; the time spent on practicing pronunciation; the number of correct words that were matched to sounds; the number of correct answers identifying capital letters; the variety of words used in the composition derived from the vocabulary section; the richness of the written descriptions based on data provided through the learning activity; the extra time used reviewing concepts at home; the level of engagement on the activity; how many students were watching what appeared on the screen; among others. Third, the goal is also to allow students to do their own assessments. Students can evaluate the percentage of the course progress that has been achieved; which activities were engaging; what media tools (video, sound, haptics, animated characters, etc.) were more useful; which activities they would like to repeat or avoid; to what degree was the digital content relevant to complete the assignments; among others.

Suggestions for Future Research

Despite the known educational potentials of augmented reality technology, how students learn from this content is still not well understood and the number of dedicated studies is insufficient [12]. First, future research is needed on learning theories applied to augmented reality. Perhaps the main question is: what are the challenges of incorporating this technology in current curriculums? Second, it is especially important to test how augmented reality supports reading skills from phonetics to comprehension. In addition, educational institutions and teachers need to know how augmented reality influences memory, imagination, collaboration, analytical thinking, among others. Third, I suggest future research on instructional design applied to augmented reality. It is essential to understand appropriate ways to create digital learning experiences. Based on the instructional design ADDIE model [10], I envision more research on each part of the process: analysis, design, development, implementation, and evaluation.

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