Interactive Multimedia-Based Educational System for Children Using Interactive Book with Augmented Reality Mohammed Abu-Arqoub, Ghassan Issa, Abed Elkareem Banna and Huda Saadeh Faculty of Information Technology, University of Petra, Amman, Jordan Article history Received: 31-03-2019 Revised: 16-09-2019 Accepted: 19-11-2019 Corresponding Author: Mohammed Abu-Arqoub Faculty of Information Technology, University of Petra, Amman, Jordan Email: abu-rqoup@uop.edu.jo Abstract: This paper describes a system's model for Augmented Reality Learning in which a traditional book is converted to an interactive book using Glyphs (TAGs) and multimedia. The interactive book can be used by a child, parent, or by a teacher to make learning an enjoyable experience. As the child goes through the contents of the book, illustrations and images come to live, thus enforcing the learning and comprehension of concepts in an interactive and fun way. To make a printed book interactive, special TAGs (Glyphs) are inserted in the required places within the book, ready to be read by the webcam and then converted to video, 2-D or 3-D images, audio and explanation text. An actual example (Sandy Starfish) is presented to illustrate the architecture and the implementation of the Augmented Reality learning system and to explain the steps and procedure used to transform a textbook to an interactive one. Keywords: Children Books, Augmented Reality, Learning, Multimedia, Glyphs Introduction Improving education has been the focus of several efforts around the world. Each of these efforts has different roots and provides different models for changing teaching and learning (Issa et al., 2014a; 2014b; El-Ghalayini et al., 2017; Black and Atkin, 1996). Over the past couple of decades, the usage of digital devices and other interactive media applications such as interactive books and video games has been added to the list of learning tools in preschool classrooms (Romano et al., 2007). Issa et al. (2010) proposed a framework of interactive satellite TV-based M-learning for constructing a cost-effective, reliable M-Learning system that can be used by large scale of learners and teachers. The Federation of American Scientists (2006) supports the use of digital devices and video games in classrooms stating that, “educational games are fundamentally different than prevailing instruction because they’re based on challenge, reward, learning through doing and guided discovery in contrast to the ‘tell and test’ methods of traditional instruction” (Romano et al., 2007). Many research papers focus on the teaching methods for such interactive environment in order to state the standards for the best way to evaluate students’ ability to be interactively involved in the class. This seems to be necessary with the distraction of connectivity environments; such as the Internet and its different applications. This can be achieved by encouraging the students to use these applications and tools in their education alongside their entertainment or social activities (Nusir et al., 2013). Another study in (Tervakari et al., 2013) concentrated on studying the effect of using the social media on enhancing students learning and cooperation. 83% of the students agreed on that using social media enhanced their learning. For the purpose of assisting teachers in determining which IT tool to use regarding time constraints of students and teachers (Lin et al., 2014) proposed an evaluating model: Analytic Hierarchy Process (AHP)- Multi-Choice Goal Programming (MCGP), the model was implemented and used in computer courses at a university in central Taiwan. Currently, learning is being highly affected by the emergent cultures of the 21st century, such as ‘blogging’, file-sharing gaming and Socializing. Attitudes of learners have shifted towards openness, self-paced learning, teamwork and have shifted away from the traditional just in class learning, Accordingly, new technologies have to be combined with traditional methods to attract learners (Tang et al., 2009; Connolly et al., 2009). Entertainment-driven learning that is more dependent on meaningful activities and exercises defined in the game context is has become a more attractive form of learning than traditional didactic approaches. Specifically, if these Entertainment-driven learning Mohammed Abu-Arqoub et al. / Journal of Computer Science 2019, 15 (11): 1648.1658 DOI: 10.3844/jcssp.2019.1648.1658 1649 approaches are based on the gaming technologies to create a fun, motivating and interactive virtual learning environment (Connolly et al., 2009). One of the most studied tools in enhancing teaching techniques is using Augmented Reality (AR) to build interactive learning environments and interactive books. An audio-visual experience is given by (Grasset et al., 2008) through building a well-known book in New Zealand “The House that Jack Built”. The system offered alternative options for users to navigate through the book using a handheld device attached with a camera or a handheld camera controlled by the user through computer screen. Although the work in (Grasset et al., 2008) concentrates on using AR in teaching environments yet many research areas take the benefit of AR in other domains such as in (Nilsson et al., 2011) where an AR system was developed to help in the cooperation between multiple parties to accomplish joint tasks. For example, in crisis management scenario where rescue services, the police and military personnel by providing organization specific views of a shared map. AR is being the core of many researches in several domains such as tracking features or objects, hybrid objects tracking systems using mobile wearable AR system that combines vision-based tracker with inertial tracker (Ribo et al., 2002), while in (Wagner et al., 2010) 6DOF natural feature tracking techniques were presented and they are suitable for phone applications. Enhancing museum visitors’ experience system was introduced in (Barry et al., 2012) where Natural History Museum, London a multimedia studio, through using AR technologies the visitors had a dynamic experience using tablets and mobile device. Hagbi et al. (2009) is another mobile phone system that uses AR to track features, where users can teach the system new shapes in real-time (Liu and Granier, 2012). Outdoor illumination variations online tracking from videos captured with moving cameras techniques were developed for AR. Two gaming systems were developed in (Ebling and Caceres, 2010) to encourage people to get involved in their cities. This paper describes the development of an interactive book using augmented reality tools which can be easily adopted by early grades teaching systems. The rest of the paper is organized as follows: Section 2 provides an overview of augmented reality in education and sheds some light on existing related technologies. Section 3 describes the proposed framework and its main features. Section 4 explains the procedure for user interaction. Section 5 describes the implementation details. Finally, the conclusions are summarized in Section 6. Augmented Reality in Education Augmented Reality, on the other hand, is a variation of Virtual Reality (VR) where participants interact with digital information embedded within physical real environment (Dunleavy and Dede, 2014). VR technology simulates real world, with virtual objects existed in the real world. Therefore, AR completes reality, rather than replacing it and virtual and real objects will seem as existing together in the real world from user’s perspectives. AR can be thought of as a middle layer between VR which is completely artificial and the physical world which is completely realistic (Azuma, 1997). Many systematic literature reviews in the area of AR in education have concluded that there is clear advantage of using AR in promoting enhanced learning achievement, despite some of noted difficulties in the usage of AR and some of the technical issues related to this technology. Many benefits have been highlighted in the research including: Improve learning at all levels, in all places and for people of all backgrounds; No special equipment is required; Higher student engagement and interest; Improved collaboration capabilities; A faster and more effective learning process; Practical learning; Safe and efficient workplace training (Yuen et al., 2011), (Wu et al., 2013), (Radu, 2014), (Bacca et al., 2014), (Akçayır and Akçayır, 2017), (Chen et al., 2017). (Masmuzidin and Aziz, 2018). (Sommerauer and Müller, 2018). Existing AR Systems in Education and Learning Marshall (2005), has shown that people and students are not willing yet to give up the physicality of a real book and hard copied material because they offer a broad range of advantages, such as: Portability, flexibility, robustness, etc. therefore and as shown by (Marshall, 2005) the future of physical books can be changed and enhanced considering the individual reader. Books can be digitally enhanced to combine the benefits of physical books with the benefits of having new interaction possibilities offered by digital media. Having the suitable combination of pedagogical structure and new technologies should enhance learning outcomes (Shirazi and Behzadan, 2013; Bower et al., 2014). Billinghurst et al. (2001; Billinghurst and Duenser, 2012) developed a magic book which enables users to see virtual content imposed over real book pages in an AR view and then transition into a virtual reality view to experience a fully emotional view of the data (Grasset et al., 2008). This methodology in AR depends on features extraction and requires a great deal of customization skills to make any hard copy material to become augmented; this proposed solution only visualizes the Objects without interaction or searching techniques. In addition, visualization was not built on a well-defined framework. Cooperstock (2001) has developed a presentertracking algorithm, which follows the instructor's movements, even when in front of a projected video screen, thereby obviating the need for a professional Mohammed Abu-Arqoub et al. / Journal of Computer Science 2019, 15 (11): 1648.1658 DOI: 10.3844/jcssp.2019.1648.1658 1650 camera operator. The system then compresses the captured video and upload it to e-learning portal. This algorithm tracks the motion of instructor but not the material itself. Incoming video stream is rendered not in real time and may be time consuming since the algorithm depends only on feature analysis. Al-Wabil et al. (2010) proposed an educational game for Children with dyslexia and attention deficit disorders who often suffer from problems with short term memory. The systems use a learning strategy to enhance short term memory even though it does not rely on using a physical book. Using AR has been also used to teach students in different levels, such as building three-dimensional dynamic geometric objects rather than depending on the traditional methods. Al-Wabil et al. (2010) developed an AR system that enables students and teachers to work on 3d-Objects which enhances students learning of complex spatial problems. Liarokapis et al. (2004) students explore 3D mechanical engineering materials through 3dWeb application. The system architecture includes a XML repository, communication server and a visualization client’s system which are built with the help of AR environment. Students could interact with machines, vehicles, platonic solids and tools to enhance mechanical engineering teaching methods.

A Model for Learning Using Augmented Reality This section presents a system called TAGtech, which constitutes a general model for using Augmented Reality with physical books. Figure 1 shows the active players in such a system: Virtual environment (tag Info, media streams and audio), supported hardware (cameras and data shows), physical contents (a book and tags images) and educational environment represented by the teacher. All these components together form the interactive book, which will be used to enhance overall student’s learning. Overview of System's Operation TAGtech has been designed to act as a platform for converting traditional books into interactive books that uses Augmented Reality concepts. This platform has been designed bearing in mind people with little or no technical backgrounds. A kindergarten teacher for example, can use the system with ease and can produce what we refer to as AR-Ready Book. This book can be used later by the teacher or even by the students themselves. Figure 2 shows a picture of “Sandy Starfish” interactive book created by this work along with the different tags used. The basic operation of TAGtech can be illustrated in the following simple steps: Creating an Augmented Reality-Ready Book This is an important initial step in which the teacher first chooses the book or story and highlights the portions of the book that may require further illustrations, using 2-D, 3-D, sound, or video (MM-Objects). The next step is to choose required multimedia files from existing sources or from the web. Once images and videos are selected and stored locally, the teacher runs the TAGtech Tag creation software. This portion of TAGtech is user friendly and easy to operate.

All what the teacher has to do is to select unused tags, upload selected multimedia files and connect each tag with each file. The Tags are then printed, cut and inserted in proper locations in the book. The AR-Ready Book is now ready for use. Running the system Once the AR-Ready book has been created, the operation of the system is straight forward. The teacher must first ensure that a proper setup is completed consisting of a PC or a laptop, a webcam connected to the PC and a Data Show projector (optional). The book can be located anywhere and, in any orientation, as long as the pages of the book are within the range of the webcam. As the teacher reads the storybook, if the webcam detects a tag in any place within the book, the multimedia file is activated. The book can be moved or rotated as the teacher wishes without compromising the appearance of the images.

System's Architecture As shown in Fig. 3, TAGtech components are built on top of three layers. The bottom layer is the Microsoft .Net Framework, followed by Aforg and Graft Library and finally the Microsoft XNA for 3-D graphics. The system consists of three major components as follows: Glyph Recognition, Glyph Creation and Projection. Glyph Recognition Components According to proposed Architecture glyph recognition is composed of the following Components: Glyph Recognizer The purpose of this component is to find all quadrilateral areas, colors or image feature and extract it from incoming camera video stream. The basic steps of this component are: Handling incoming stream and take Frame N (FN) as still Image, Recognize Marker directly from fn, Extract Marker from the source image M1 and then Separate square image for each potential Marker, containing only Marker data. This component will use some image processing Techniques such as Otsu thresholding, Difference Edge Detector and Quadrilateral Transformation algorithm.

Glyph Database The Glyph database consists of three tables containing the tags (Glyphs) and their associated binary matrix (0’s and 1’s), multimedia objects information linked to tag table and linked to physical multi-media files existing in the repository and finally a table containing the type of the multi-media object for later use in displaying or activating the object. Figure 4 shows a schema diagram for the glyph database. It is important to note that all the tags stored in the database have a “rotation variant property” to allow the system to recognize the tags scanned by the web camera even if they were tilted or rotated. This process is further explained in later sections.