Interactive Education using Augmented Reality Powered Mobile Application

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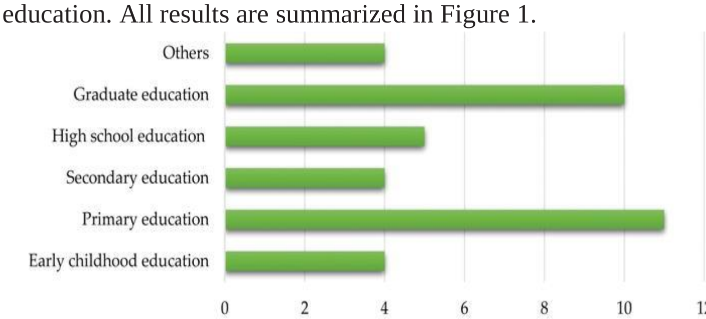
Abstract **In recent years Augmented Reality (AR) has developed rapidly and is widely used in education teaching due to its strong sense of immersion and interaction. In this context, this paper analyzes the key technologies of AR and designs a complete display system of Earth, human skeleton and ability to add any subject with interactive functions. Specially, this system is packaged into an android app where The Egyptian Ministry of Education provided android devices for students. In our application we used Unity as main platform, Blender to create our graphic content (3D models) and Vuforia SDK based on marker then it was converted to Mark-less AR. We also modified scripts using visual studio and converted our work to mobile application with built in android studio. We created three models (1) Earth (2) Skeleton (3) Creeper and put all parts and explanations on models. And we could zoom in/out model to view more details about models and we could rotate and move models from its location, and users could listen to explanation which make learning easier. After all, we can add many fields of education with many virtual objects. Marker-less Augmented Reality's ability to overlay digital information on the real world is a boon to educators, who are using the tools to better illustrate complex concepts for students. And from its education becomes more enjoyable and beneficial.**

I. INTRODUCTION

AR technology is an extension of Virtual Reality (VR) technology, which allows users to see the virtual generated model objects in the background of the real environment [1]. We applied it in education aspect. This interaction technology is based on the real world and is enhanced by virtual data which provides people a better way to display the learning content, and also builds a space for learners to explore independently with a more appropriate way. Because of its characteristics, AR technology has great potential and opportunity for development in education field. The characteristics of AR technical simulation and interaction can display the abstract and obscure knowledge in a more vivid, intuitive and comprehensive way, and can enhance students' sense of immersion. AR technology can take content out of the screen and books with more entertainment and interactivity. AR digital publishing will become an explosive opportunity for the culture education industry. The mobile AR system can strengthen the ubiquitous cooperative and scene learning with the help of virtual objects in the real environment. Everything in real life can become a prop for AR learning, achieving convenience, interactivity, situation, connectivity and personalization. With the coming of the shallow reading age, more and more learners become less dependent on books and more inclined to the shallow reading of electronics. AR technology can take content out of the screen and books with more entertainment and interactivity. AR digital publishing will become an explosive opportunity for the culture education industry. From 2016 to 2017, 38 articles were analyzed from many different journals, including EURASIA Journal of Mathematics Science and Technology Education (5), Interactive Learning Environments (5), Computers & Education (4), British Journal Of Educational Technology (4), Journal of Computer Assisted Learning (2), Education and Science (2), Education Tech Research Dev (2), Asia-Pacific Edu Res, IEEE Transactions on Learning Technologies, Australasian Journal of Educational Technology, BMC Medical Education, Croatian Journal of Education, Digital Education Review, Early Child Development and Care, Innovations in Education and Teaching International, International Journal of Science Education Part B Communication and Public Engagement, International Journal of Serious Games, International Journal of Emerging Technologies in Learning, Journal of Geography in Higher Education, Revista Iberoamericana de Educación a Distancia, and Journal of Research on Technology in Education. Firstly, level of education used in these reviewed studies has been investigated. Results show that AR technology has been mostly carried out in primary and graduate education. On the other hand, early childhood education and secondary school education need further research regarding using AR in education. All results are summarized in Figure 1.



	Early childhood education	Primary education	Secondary education	High school education	Graduate education	Others
Target group	4	11	4	5	10	4

Figure 1. Target group of reviewed articles.

Material types of AR used in education have been examined in reviewed articles. Mobile applications (f = 16) and marker-based materials on paper (f = 12) have been mostly preferred in them. Besides, some of the studies have used AR picture books and AR game systems. Related results are stated in Figure 2.

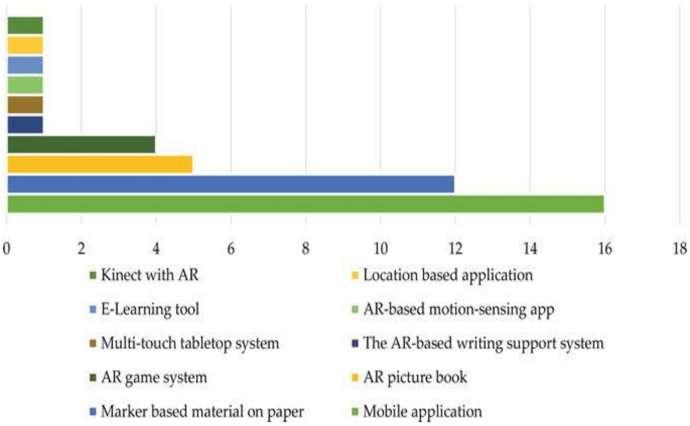


Figure 2. Material types of AR used in education.

Reported Educational Advantages of AR" has been explored as another category. Table 1 shows the results regarding them in the articles analyzed. As one study can indicate more than one advantage, total frequency of them is high. The results show that major advantages indicated in the articles are: "Learning/Academic Achievement" (f = 23), "Motivation" (f = 9), and "Attitude" (f = 6). Also, many variables, such as academic procrastination; writing skills; cognitive aspect; the number of errors they made; ability to remember the content; page design; teachers' acceptance and views; potential uses of augmented reality in education; social, emotional, and cognitive improvement; story comprehension performance; time spent; acquired learnings; metacognitive perception; experiential activity; and prospects of the use of AR for study, have been focused in reviewed articles by researchers [2].

Table 1. Reported educational advantages of AR.

Advantages	Number of studies	Percentage (%)
Learning/academic achievement	23	34.33
Motivation	9	13.43
Attitude	6	8.96

Before starting in the application, we made a survey with many students in different age groups. This survey included questions like, (1) What do you prefer book or tablet?, (2) Have you ever tried to search on the Internet for a picture or video of something you have studied?, (3) If the school makes a field trip for the purpose of entertainment and learning about a specific lesson about geography or history, would you like to participate in it?, (4) Which is better for you to read or listen?. Figure 3 shows all results.

II. Methods and Material

Unity is a game engine It is a multi-platform game development tool, a fully integrated professional game engine, and can provide such functions as rendering engine, physical engine, script engine, lighting mapping and scene management. Unity is mainly used to create games and interactive 3D and 2D experiences such as AR learning, medical and structural visualization. We created skeleton and Earth as two subjects in our application. It is available to add more subjects.

A Unity program is composed of several scenes, each of which contains many models (GameObiect) and their behavior which is controlled by scripts (including JavaScript, C#, etc.). Every GameObject has C# script for its function we modified these scripts to be suitable with our needs for applications using visual studio.

Blender can be used to create 3D visualizations

3D modeling: is a technique in computer graphics for producing a 3D digital representation of any object or surface [3]. **Unwrapping and Texture**: A UV map is the flat representation of the surface of a 3D model used to easily wrap textures. The process of creating a UV map is called UV unwrapping. The U and V refer to the horizontal and vertical axes of the 2D space, as X, Y and Z are already being used in the 3D space [4]. **Rigging & Animating**: Rigging is a technique used in skeletal animation for representing a 3D character model using a series of interconnected digital bones. Specifically, rigging refers to the process of creating the bone structure of a 3D model. This bone structure is used to manipulate the 3D model like a puppet for animation.

We need to use more advanced 3D models in our application and it's not easy to implement them, so we needed to get implemented models from stores but we faced some problems. We need separable and animated 3D models and these models are so expensive, the price ranges (20$ - 100$) and free models usually not separable, so we decided to take these models and modify it using blender to be suitable with our needs and provides expensive cost.

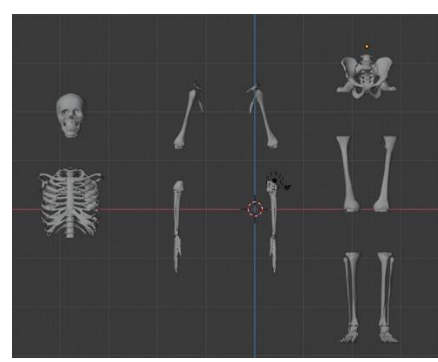


Figure 3. Separable Skeleton

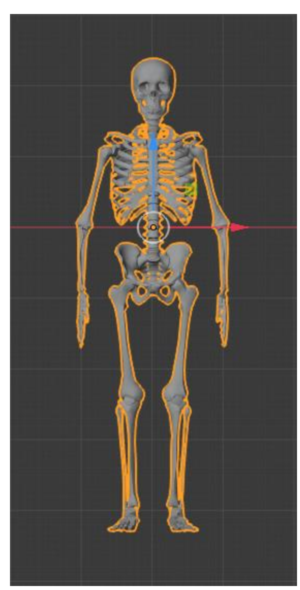
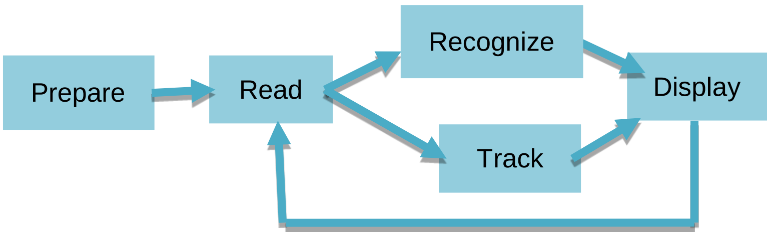


Figure 4. Skeleton free asset (One part)

Vuforia is an augmented reality software development kit (SDK) for mobile devices that enables the creation of augmented reality applications. It uses computer vision technology to recognize and track planar images and 3D objects in real time. This image registration capability enables developers to position and orient virtual objects, such as 3D models and other media, in relation to real world objects when they are viewed through the camera of a mobile device. The virtual object then tracks the position and orientation of the image in real-time so that the viewer's perspective on the object corresponds with the perspective on the target. It thus appears that the virtual object is a part of the real-world scene. This was our first technique to display our 3D model in real world within mobile camera.



Prepare: • Load Reference/Target Image • Extract Features • Initialize Camera. **Read**: • Capture Camera Frame • Extract Frame Features. **Recognize**: • Match Features • Remove any Outliers • Find Transformation. **Track**: • Use Point Tracker • Find Transformation between frames. **Display**: • Apply Transform • Combine [5].

Then we converted from Vuforia (Marker based AR) to Marker-less AR which makes application more professional and we didn't need image target to display models. SLAM (Simultaneous Localization and Mapping) is a technology used to achieve marker-less AR it understands the physical world through feature points. The device's sensors collect visual data from the physical world in terms of feature points. These points help the machine distinguish between floors, walls and any barriers. Measurements are constantly taken as the device moves through the surroundings and SLAM takes care of the inaccuracies of the measurement method by factoring in 'noise'. Different sensors use different algorithms. SLAM largely makes use of mathematical and statistical algorithms. One of which is the Kalman filter. Kalman filter takes into account a series of measurements over time, instead of just a single one. It then predicts the position of unknown variables, in our case – unknown points on 3D objects in the device's point of view. Inertial measurement unit (IMU) is the sensor used in mobile devices to estimate the pose (position and orientation) of the camera relative to the world over time [6].

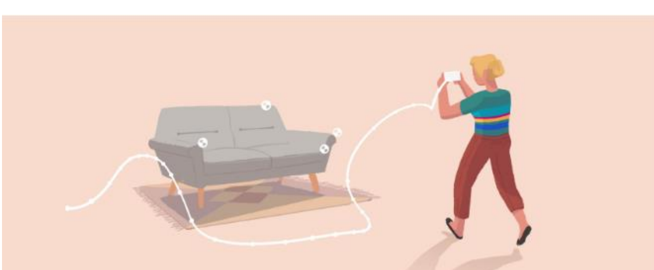


Figure 6. The device's sensors collect visual data from the physical world

Clusters of feature points that appear to lie on common horizontal or vertical surfaces, are likely to be tables or walls, thus surfaces and planes are detected, flat surfaces without texture, such as a white wall, may not be detected properly. This makes it possible for AR applications to recognize 3D Objects & Scenes, as well as to Instantly Track the world, and to overlay digital interactive augmentations.

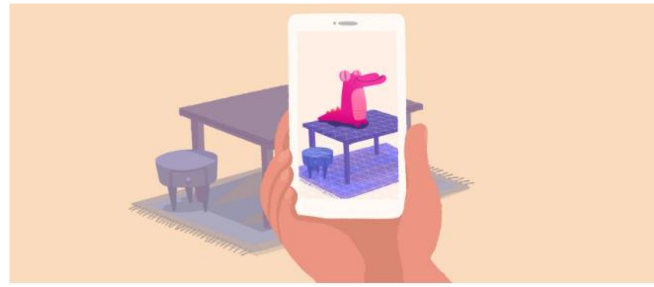


Figure 5. Augmenting 3D object on to horizontal plane (table) in the physical world

We combined between the two methods (Marker based and Marker-less) in our application so that users can have the luxury of choosing the AR experience [7].

III. RESULTS

After creating 3D models and importing them to unity platform, then we started to select Augmented Reality SDKs (Marker based and Marker-less) which will show our output. At first, main menu is showed and user should option which need.

A. Marker Based

When mobile defines the image target, models will appear on image target. And user should press on model which wants to see model individually and control in model rotating, moving, scaling and animating. And could select certain part to know more details about it.

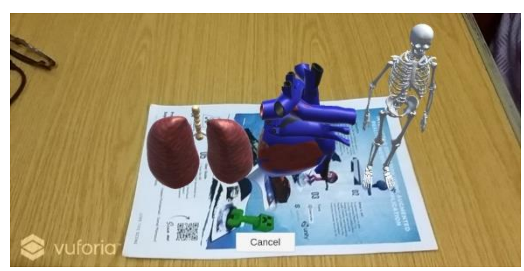


Figure 7. Models on image target

Figure 8. After user select model, it appears on target and user can get close to model, scale and rotate. user can press on any part to read more information about it

Figure 9. When user pressed on skull to know more details.

B. Marker-less

Once the user selects Marker-less AR, an AR session begins, the user is instructed to move the device and point the camera towards horizontal planes in the physical world around him so that the application can detect horizontal surfaces and planes. Once a plane is detected a virtual plane appears representing the detected plane.

The user now can select a model from the side panel and place it on the detected plane. Multiple instances from selected model can also be placed as well as different models with multiple instances.

Figure 10 Plane Detected

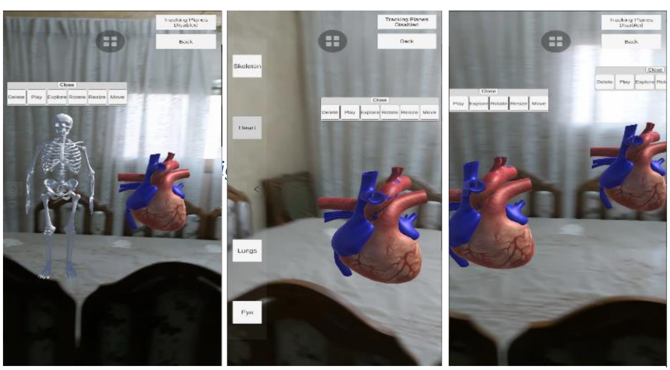


Figure 11 Placing different models and multiple instances of the model

When Clicking on the object a pop up menu appears that allows the user to manipulate and explore the object throw various buttons in the pop up menu, Pressing Explore button activates information panel providing user with information that user can select to hear in English or Arabic, pressing on each part changes information relative to the selected part.

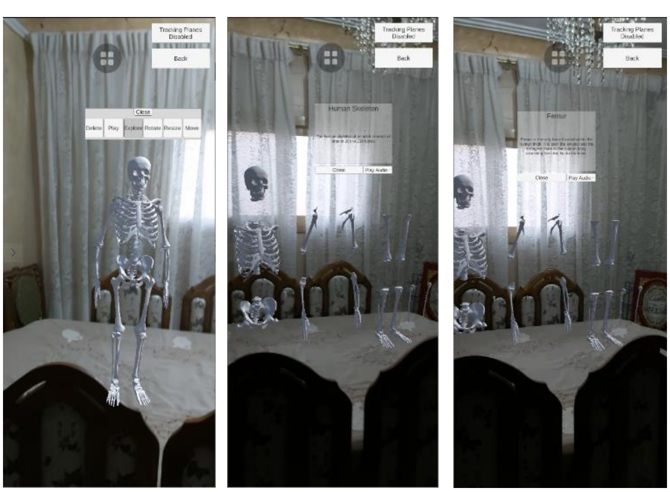


Figure 12 Popup Menu activated on touching the skeleton model including control buttons and Information Panel showing info about femur that the user selected

IV. Conclusion

There are two block diagrams showing our work.

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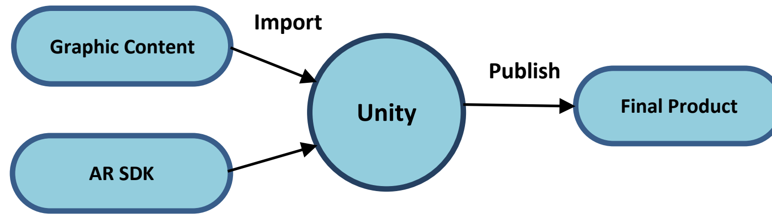

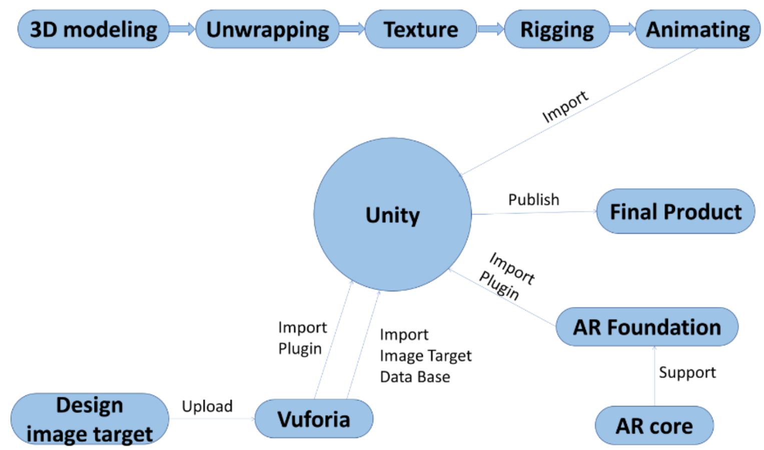

V. Refrence

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