Comparative Study of Conventional Methods and Augmented Reality: Effects on Class Performance

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ABSTRACT

This paper presents a comparative study between Conventional Methods and Augmented Reality. Pakistan is moving towards becoming a developed nation. As such, the need for adequate human resources in science-related fields is one of the requirements to achieve a developed nation status. The aim is to use the gaming habits of young generation in helping them learn about their courses like Mathematics, Science, English and General Knowledge. This will give them a head start in their studies and help them have an easier time studying which is evident from the results discussed at the end of the paper. Students who learned from augmented reality performed much better in tests cases compared to those who learned through conventional methods. Overall, the results show that the students benefited from the use of the conventional and relevant learning approaches.

Keywords: Augmented Reality, Virtual Reality, Data Flow Diagram, Vuforia, Voice Recognition, Speech Synthesis.

1. Introduction

The word augmented reality goes back to 1990 when Thomas P Caudell described it as computer-generated diagrams that are positioned on a real-world object [1]. Since then the development and demand of augmented reality sky rocketed in fields like medical sciences and engineering. Augmented reality is being used for multiple types of surgeries and other medical analysis like the management of intracranial tumors and dental care augmented reality makes it easier to analyze these things 3-dimensional space. [2-3] Augmented reality also used by many organizations for training purposes and productivity like reviewing a 3D model before manufacturing it. Architectural engineers also use augmented reality to check the structural design of buildings before the actual physical prototype is built which increases their productivity and same goes for automobile giants like Bavarian Motor Works (BMW). [4-7] All of this progress is a result of improved productivity.

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One of the biggest applications of augmented reality which is often neglected is its ability to educate student in an interesting way. The reason of this theory being less popular is because of the fact that there is a very low probability of revenue from these type of products for tech giants. One of the biggest hurdles in learning process is memorization and according to University of Maryland a research was conducted that proved it is easier to memorize using visual representation which prove augmented reality very effective in learning as it totally depends upon visuals. Researchers at University of Maryland made an immersive environment in virtual reality that lead to the result that it could offer new pathways for improved outcomes in education and high-proficiency training. [8] Some children have specific Learning Difficulties, so Jessie Francis Williams focuses on a research into the possibility of early identification of children of normal intelligence, with learning disorders believed to evolve from neurodevelopmental dysfunction, but the catch is an improvement can still be made using unconventional methods like Augmented Reality and Virtual Reality. [9]

Augmented reality animated content in classroom lessons could catch students’ attention in our dynamic day and age, as well as motivate them to study. Adding extra data, e.g. a short bio of a person, fun facts, historical data about sites or events, visual 3D models, would give students a wider understanding of topics. AR technology has an ability to render objects that are hard to imagine and turn them into an interactive 3D environment that blends with the real environment, thus making it easier to grasp the abstract and difficult content. This is especially good for visual learners and practically anyone to translate theoretical material into a real concept.

2. literature review

There is an application called wonder scope that detects a flat surface and display 3d models on it. The application is used to teach students all the stories in visual representations also teach them about some major concepts related to science and technology. This app is considered very important for educational purposes as it is a very direct approach towards learning. [10]

![Fig. 1. Wonder scope storytelling.](image)

Layer is another application that use augmented reality to make greeting cards and brochures interesting and easy to learn and understand. This application uses another method to make augmented reality work in this method a surface that have some sort of pattern on it like a greeting card have a specific design and then it recognizes the pattern to display 3d objects on it [11].
Fig. 2. Layer using augmented reality to give locations of specific places

Shapes 3d is an interesting application that uses the some 27 objects with different shapes to give people a more diverse 3d drawing experience which is a way more fun than Lego blocks yet it can make more complex structures because of its ability to change any angle of a block and yet it also give users the ability to add hundreds of blocks in different positions.[12]

Fig. 3. Shapes 3d drawing.

Google also made their mark in this area as they introduced google expeditions which lets the user to go to any place in the world also let the users learn about different things like animals etc. in a beautiful and an immersive 360° environment. It is very important and useful for studies related to geography. This app lets you imagine the full 3d environment so you can use that information to teach and learn. [13]

Fig. 4. Solar system using google expeditions.
Snapchat uses augmented reality to give augmented reality based 3d filters that maps to the user’s face. These filters are entirely used for entertainment purposes only. Yet millions of people use these filters to entertain each other. [14]

All of the above applications are very important and useful but almost all of them does not use a direct approach towards learning. This is a very big loophole as none of these applications will get a chance to be used regularly in the classroom. These applications are mostly used to as a showcase of modern technology for younger audience. There is a point that must be raised how to incorporate these technologies in the real-life classroom environment and what effect will it have on children?

Our approach for the augmented reality E-Learning application is a bit different child must learn their intended course outline in an interesting and fun way. For this purpose, all the content was taken from four different subjects i.e. General knowledge, Mathematics, English and science. These subjects are the most common subjects and are important for personality grooming. For entertainment purpose four famous characters were selected that will represent these subjects. Marco Polo represents general knowledge, Alan Turing represents mathematics, Isaac Newton represents science and Shakespeare represents English.

3. Methodology

Tools
Some of the tools used to make this application are:
   a) Unity 3D
   b) Vuforia
   c) Photoshop
   d) GIMP
   e) Inkscape
   f) Paint 3D
   g) Blender
   h) Visual Studio
   i) Physical Camera

3.1.1 Unity
Unity is basically a game development engine that is able to build games for web, IOS, Android OS, Windows OS, Linux OS, Mac OS, TV OS, Xbox One, PS4, Facebook etc. Unity is the game editor which is used to make this application. All the other softwares are either integrated with Unity or are compatible with Unity.

3.1.2 Vuforia
Vuforia is an augmented reality-based engine that is compatible with multiple softwares one of them is unity it adds on to unity as a plugin and it uses unity’s powerful game developing engine to project 3d models and embed real time physics. This engine can also be directly connected to android studio. The way of using Vuforia is very simple. First step is to find a pattern that has enough variation to get recognized it is even rated in Vuforia website portal. The rating of a picture describes its ease of recognition by the algorithm provided by Vuforia. The database is then created that contains all the
codes generated for that specific pattern to recognize. Those codes when imported to Unity works as a data set. As soon as the plugins are installed and the data set are imported the augmented reality starts all of its functionalities. Any model imported is projected on the plane.

**Fig. 5.** Rating shows how easily it is recognized by the algorithm.

### 3.1.3 Blender
Blender was used to make 3d models, if royalty free 3d models were not available on unity store or anywhere on the internet.

### 3.1.4 Photoshop & GIMP
Both of these tools are used for similar tasks to make artificial texture for some the 3d models, make 2d sketches to decorate and apply different filters etc. to enhance image quality.

### 3.1.6 Inkscape
This software was used to make Icons and smaller bits in the augmented reality application.

### 3.1.7 Paint 3D
It is a pre-installed software in Microsoft Windows that gives a versatile editing experience. The interesting part in that software is the 3d text editor that give the user a way to easily write 3d text and save it in the fbx extension. All of our 3d models are in fbx format.

### 3.1.8 Visual Studio
The programming editor we used is Visual Studio as all the programing is done using C# and Visual Studio editor uses C# in as a default programing language which is more efficient so it was used instead of MonoScript Unity.

### 3.1.9 Physical Camera
Any sort of high-resolution camera can be used for pattern recognition so for this purpose we used 8 Mega pixel webcam and 13 Mega Pixel back camera of smart phone.
3.2 Flow

When the application starts it welcomes the user giving the user a voice generated commands/instructions about the application. After the user touches or clicks depending on hardware two other menus appear play and settings.

![Welcome screen](image1)

**Fig. 6.** Welcome screen

3.2.1 Play

This is the main option which leads you to playing. After clicking this user is led to a screen where there is a selection between augmented reality and normal game mode. All of these menus are colorful to make them as attractive as possible.

3.2.2 Settings

In settings you can adjust audio and graphics settings. In graphics setting user can either select anti-aliasing and set it to on or off state.

![Play and setting menu](image2)

**Fig. 7.** Play and setting menu.

3.2.3 Normal mode

This option leads the player to the world selection screen. The world selection is basically a screen where user select subjects. A subject is denoted by a world in this case. In normal mode the user is
given the same content without using augmented reality. That mode is still interesting but it cannot give you the level of detail augmented reality provide.

3.2.4 Augmented reality mode

This option leads the player to the world selection screen for augmented reality. The world selection is basically a screen where user select subjects for augmented reality. A subject is denoted by a world in this case. Augmented reality has its own menu while navigating that gives the user a feeling of being inside this immersive world.

![Fig. 8. Normal and augmented reality mode menu.](image)

3.2.5 Polo world

This world is based on general knowledge. It is named Polo world after a famous explorer Marco Polo who used to travel the world. This led us to its name. Each world will have multiple levels. Clicking on any of those will start that respective level. The player must either complete the objective or exit to leave the level. Completion of all the missions will lead to the players winning.

3.2.6 Newtonian world

This world is based around science. As Newton was a famous Physicist, we based the name on him. Each world will have multiple levels. Clicking on any of those will start that respective level. The player must either complete the objective or exit to leave the level or mission. Completion of all the levels will lead to the players winning.

3.2.7 Turing world

This world will be based around Mathematics. As Alan Turing was a great Mathematician, we based the name of the world around him. Each world will have multiple levels. Clicking on any of those will start that respective level. The player must either complete the objective or exit to leave the level. Completion of all the levels will lead to the players winning.

3.2.8 Shakespeare world

This world will teach the children English. As William Shakespeare was known as one of the best men to speak English, we named this world after him. Each world will have multiple levels. Clicking
on any of those will start that respective level. The player must either complete the objective or exit to leave the level. Completion of all the missions will lead to the players winning.

Fig. 9. Subject selecting menu in normal mode.

Fig. 10. Subject selecting menu in augmented reality mode.
Fig. 11. Activity Diagram

Fig. 12. UT DFD Level 0

Fig. 13. UT DFD Level 1
4. Features Overview

There are different functions that help this application being more interactive than any normal application of this type.

4.1 Augmented Reality

The user gives a piece of paper that has a specific pattern on it. The application recognizes the pattern and displays a 3d object on it accordingly. The angle of 3d models change with perspective of the pattern that is given on the paper. The application can run on multiple platforms and is very accessible to all types of audience. For this purpose, the Vuforia plugin is used.

4.2 Voice Recognition

The application uses voice recognition to interact with students in more meaningful ways, the whole application can be used without even touching or clicking the screen. Unity’s offline speech synthesis is being used to manipulate through menus and the application itself.

4.3 Speech synthesis

The application interacts with user through an easy menu system and speech that guides the user through the menu in case if the user is not familiar with the environment. Speech synthesis is mostly used to guide the user as our users are the younger audience and it makes it easier for them to navigate.

4.4 Physics

Thanks to the powerful unity engine we were able to put in real-time physics into the application that makes the levels even more fun, realistic and relatable.
4.5 Light management

It is a management system to turn on lights. It Highlights the current selection. For example, while navigating through a Ray Cast which is always on directed where our mouse is pointing. Whenever it finds an object that is clickable the object will detect that it is being pointed at and it will light up or highlight the object being pointed towards. This will give the player an idea of what can and cannot be selected.

This method is used throughout the application.
4.5 Clickable Objects

Ray Cast have a list of all the objects which are clickable and consistently checks for them and when it intersects a clickable object it performs actions accordingly. We have coded the Ray Cast to highlight any clickable objects this would give the player an idea that this is a valid selection entity. If they detect that they are being pointed towards, they don’t do anything until the user click a mouse button. There are two ray casts used for the mouse pointer. One which is always on and one which functions only upon click. When a clickable object detects it has been selected and then we click it does what it is supposed to do.

4.6 Voice over

This feature gives user helpful hints on how to navigate the menu. This can also be turned off if someone gets the idea of how to navigate the menu. We have used an artificial voice which is both very clear and has an accent which is easy to understood.

4.7 Click Sounds

We have also included click sounds in our project. These are smart click sounds, as if we click on an unclickable object there will be no sound played, but if we click on a clickable object, we can hear the sound.

4.8 Changing Camera Position

When the user clicks an option it actually changes the cameras position to a menu corresponding to the button you clicked. Same is the case with some levels it actually changes the camera to the level you want to play. This changing of cameras is done in such a way that the user feels like the whole scene is being changed but in fact it is just the cameras location which is being changed.

4.9 Moving to next game scenes

This also uses the help of both ray casts and multiple cameras. When the user completes a mission objective, the user is given an option of 3 buttons. One is replay, which resets the mission the user is currently on or just recently finished. The second button is a close or quit button upon pressing of which the user return to the mission select scene so the user can select any other mission if the user wants to or simply change the level mode. The third button is the next button and it simply moves the camera to the new game scene which is of the next level.
4.10 Going back to previous menus

A button is included for going back in almost all the game scenes included in this build of the application. It is so that we have easier navigation and can return to the previous menus. We have also taken care so that it is not very obtrusive so it doesn’t get in the way of the user.

4.11 Audio on/off control

We have included a button which is multi functioned. It basically turns the voice assistant off or on depending upon its state. We have to note that this does not affect the applications other audios it is just intended for the voice assistance so that if a user wants to play the game with or without the voice assistance sound. The game voice as said earlier will be unaffected and can be silenced through the settings menu if desired by the user.

![Fig. 16. This button turn audio on/off.](image)

4.12 Select menu bar

In the subject select menu the user can select one of the four subjects. This screen is the screen which displays all four subjects available. The subject’s titles are buttons with ray cast detection enabled so they highlight when the user hover our mouse over them and when they produce sound and take the user to the game scene corresponding to the level fig.9 and fig.10.

4.13 Speech recognition usage

This application also has the voice recognition feature in this application. With its help the user can give commands to communicate with the 3D model. For example, if the user says “Rotate” the 3D model will be rotated in a specific direction for better viewing of just to view it from a different angle.
4.14 Level Selection Menu

In the level select menu the user can select one of the many available levels. This screen is the screen which displays all the levels available in a particular subject or world. All the level titles like subject titles are buttons with ray cast detection enabled so they highlight when we hover our mouse over them and when they produce sound and take us to the game scene corresponding to the level.

Fig. 17. The user can select different levels directly.

5. Pseudocodes:

Clicking Mechanisms

// iteration1 & iteration2 & iteration3 = 0

// clicklableObjectsName is an array which have all clickable object //names

// submenuObjectsName is an array which have all submenu object names

// submenuPosition is an array which have info about submenu object //locations

// gameSceneName is an array which have all gamescene object names

Ray-Cast projected from camera with cursor position

IF Ray-Cast intersects object collider

objectName = name returned by Ray-Cast

FOR each element in clicklableObjectsName array

IF objectName == clicklableObjectsName[iteration1] THEN

lightObject[iteration1] = activated

IF mouseButtonClick == true THEN
FOR each submenuObjectsName array

    IF objectName == submenuObjectsName [iteration2] THEN

        clickSound = activated
        cameraPosition = submenuPosition[iteration2]

        ELSE

        END IF

    Iteration2 increment by 1

END LOOP

FOR each gameSceneName array

    IF objectName == gameSceneName [iteration3] THEN

        clickSound = activated
        currentGameScene = gameScenes[iteration3]

        ELSE

        END IF

    iteration3 increment by 1

END LOOP
ELSE

END IF

iteration1 increment by 1

END LOOP
ELSE

END IF

Voice command Mechanisms

// iteration1 = 0

// voiceCommandsInput is an array which have all saved commands object
// operationsList is an array which have all the operation object names

IF user give voice input

inputVoice = voice input by user

FOR each element in voiceCommandsInput array

    IF inputVoice == voiceCommandsInput [iteration1] THEN
        operation= operationsList[iteration1]
        pass operation var to operations() function to complete the task
    ELSE
        END IF

iteration1 increment by 1

END LOOP

Audio management system

// iteration1 = 0

// musicList is an array which have all the soundtracks saved

// voiceAudioList is an array which have all the voice audios saved

As soon as the level loads up

level = fetch level name

FOR each element in musicList array

    IF level == musicList [iteration1] THEN
        musicList [iteration1] = activate
    ELSE
        END IF

FOR each element in voiceAudioList array

    IF level == voiceAudioList [iteration1] THEN
        voiceAudioList [iteration1] = activate
    ELSE

END IF

iteration1 increment by 1

END LOOP

Selection Menu

// iteration1 = 0

// clicklableLevelNames is an array which have all level names

// gameScenes is an array which have all gamescenes saved

Ray-Cast projected from camera with cursor position

IF Ray-Cast intersects object collider

objectName = name returned by Ray-Cast

FOR each element in clicklableLevelNames array

IF objectName == clicklableLevelNames [iteration1] THEN

lightObject[iteration1] = activated

currentGameScene = gameScenes[iteration1]

ELSE

END IF

Iteration1 increment by 1

END LOOP

Correct answer detection

// flag = 0

// answersList list of names of all the result

As soon as selection menu loads up

level = fetch level number

answer = answersList[level]

IF click on clickable object && flag == 0
clickedObjectName = name of object clicked

IF clickedObject == answer THEN

    Flag = 1

    Display goto next menu, previous menu and replay

ELSE

    END IF

ELSE

    END IF

IF click on clickable object && flag != 0

    clickedObjectName = name of object clicked

    IF clickedObjectName == “Replay” THEN

        Flag = 0

        Reset the level

    ELSE   IF clickedObject == “Next” THEN

        Flag = 0

        Go to the next game scene

    ELSE   IF clickedObject == “Back” THEN

        Go back to main menu

    ELSE

        END

END
Chapter 2 Results

Fig. 18. First class performance using conventional Methods vs AR.
**Fig. 19.** Second class performance using conventional Methods vs AR.

**Fig. 20.** Third class performance using conventional Methods vs AR.

**Fig. 21.** Forth class performance using conventional Methods vs AR.
All the above results are taken from actual classrooms for the most authentic results ranging from 3rd grade to 4th grade students. We can easily deduce that AR is a very powerful tool to teach students as all the questions asked through augmented reality got better response and that is why most of the students got the answers right. There are still some issues with AR like question number 20 in 4th class got a very low score in augmented reality mode and the reason was simple there are some questions that are harder to grasp in digital world that is because of some deceiving traits of the scenario. For example, in this question many students were confused because of the size of the planets.

**Fig. 22.** Fifth class performance using conventional Methods vs AR.

**Fig. 23.** Question taken from application.
As normally the size of planet earth is bigger and, in the question, they are all the same so these types of mistakes should not be carried out.

Out of 184 students who attempted 3680 questions 1945 students got the right results on paper while in AR mode 2993 students got correct answers. 52.85 % students got the answers right on paper while 81.33 % students got the right answer in AR mode. Which gives us 28.48 % improvement.

These are some of the questions taken from the application.

**Fig. 24.** Question taken from application.

**Fig. 25.** Question taken from application.

**Fig. 26.** Question taken from application.
6. Conclusions

This application has a great impact on children as they were able to produce better results in their classes without requiring any extra amount of teaching required. Children also interacted more and took more interest in studies while using the technology. These types of applications can improve the standards of learning exponentially specially for students with disabilities. During the test it was noted that the children were fully connected to the environment. It does not make our conventional methods obsolete but rather open doors to new methods of teaching that are more suitable for different people because of the relatability and interest. Schools should start using these AR applications to encourage students to be more creative and productive.

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References